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Fire History of Glacier National Park North Fork Flathead River Drainage

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FIRE HISTORY OF GLACIER NATIONAL PARK:
NORTH FORK FLATHEAD RIVER DRAINAGE

Final Report

Supplement 22-C-2-INT-20

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Systems for Environmental Management

Submitted in fulfillment of Section II, Part H of Supplement 22-C-2-INT-20 between USDA Forest Service, Intermountain Forest and Range Experiment Station, Northern Forest Fire Laboratory, Missoula, Montana, and Systems for Environmental Management.

ABSTRACT

In June 1982 Glacier National Park began a fire history study in the northwest portion of the park, in the predominantly *Pinus contorta* and *Pseudotsuga menziesii*/*Larix occidentalis* forests of the North Fork of the Flathead River drainage. The goals were to determine past fire frequencies and general intensities, as well as the impacts of fire suppression, with the resultant data being a prerequisite to the revision of the fire management plan.

The 272 fire scar samples from a 60,000 acre (24,292 ha.) study area revealed 66 fire years over the past 500 years. Results indicate a relatively frequent occurrence of extensive fires during the 271 years of the continuous Master Fire Chronology, from 1655-1926. Many of these fires were largely underburns, followed by occasional severe stand-replacing fires which often burned tens of thousands of acres, or more.

Few acres have burned in North Fork ecosystems since efficient fire suppression began in about 1930. Ecological impacts of suppression apparently are not yet substantial, however, since most of the area burned in the decades just prior to the beginning of fire suppression. In line with the National Park Service policy of perpetuating natural processes, Glacier National Park is therefore in a good position to re-introduce fire before substantial ecological impacts occur. This study provided a number of management implications to consider in planning for prescribed fires and natural fires in North Fork

forests.

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INTRODUCTION

In line with USDI National Park Service (NPS) fire management policy (Kilgore 1976), one of Glacier National Park's (GNP) major objectives is to restore fire to a semblance of its primeval role, to perpetuate naturally functioning ecosystems. GNP developed an environmental assessment in 1978 which showed that managers were more carefully considering fire's natural role. This included designation of a zone within which lightning fires would be allowed to burn under prescription ("natural fire zone"), but that zone was never clearly presented in public documents. Informally, it is said to be about 100,000 acres (40,486 ha.) of the park's westside, generally confined to high elevation ecosystems near the Continental Divide. Fires have not been allowed to burn in this zone, however, because the fire prescriptions have not yet been developed.

Additionally, the park has considered establishing a small buffer zone near park boundaries where planned ignitions might be used as a safe alternative to lightning fires. This zone likewise has not been well defined, but one small prescribed burn was conducted in GNP in the spring of 1981.

The park's managers have been uncertain about what fire's past role was; for example, how often and how intensely fires burned in different vegetation types. They also have been unsure and, therefore, cautious about how to allow lightning fires or prescribed fires to burn. Fire suppression has thus continued to be GNP's basic policy in the absence of a workable plan.

In response to these questions about fire's past role, GNP began a fire history study in June 1982, with the cooperation of the USDA Forest Service Intermountain Forest and Range Experiment Station (Northern Forest Fire Laboratory), and Systems for Environmental Management. The park's managers are now updating the fire management plan and have recognized that fire history research provides important baseline data for planning. Prescribed fire research also has been initiated, with the aid of the Intermountain Station and the University of Montana. These studies will help determine the appropriate mix of lightning fires, prescribed fires, and fire suppression in the park, and also will help determine fire prescriptions.

OBJECTIVES

The general objectives of this study were to determine the fire history of GNP's westside forests below 6000 feet (1860 m.) elevation; specifically, in the North Fork of the Flathead River drainage, excluding the Apgar Mountains. Specific objectives were to:

(1) conduct a field survey of fire history in a large representative study area by using a transect system for sampling fire scars and designating sample stands;

(2) document the age-class structure of stands as an index to fire history;

(3) construct a Master Fire Chronology for the study area, for sample drainages, and for designated

small stands;

(4) inventory habitat types, inventory stand succession relative to fire history, and obtain fuel estimates in the stands by using a photo guide system;

(5) prepare a report discussing GNP fire history, including fire maps, past fire frequencies, fire severities and effects, general fuel appraisals, and the effects of modern fire suppression. This report also would discuss management implications relative to the fire history.

STUDY AREA

An approximately 60,000 acre (24,292 ha.) study area was selected in the northwest portion of GNP, in the North Fork of the Flathead River drainage (fig. 1). This area was chosen for 2 reasons: first, the west side of the park is generally more susceptible to severe forest fires than is the east side, which has a drier, more continental climate and therefore is less productive vegetatively (Habeck 1970); second, a very severe mountain pine beetle (*Dendroctonus ponderosae*) epidemic began in the area in about 1972 and this has killed about 80% of the North Fork's extensive lodgepole pine (*Pinus contorta*) forests, or about 170,000 acres (68,826 ha.) (McGregor et al. 1981). Many area residents and some agency managers have been concerned about a possible hazard of imminent forest fires, so this area was a logical place to begin the park's fire history research.

Figure 1. Location map.

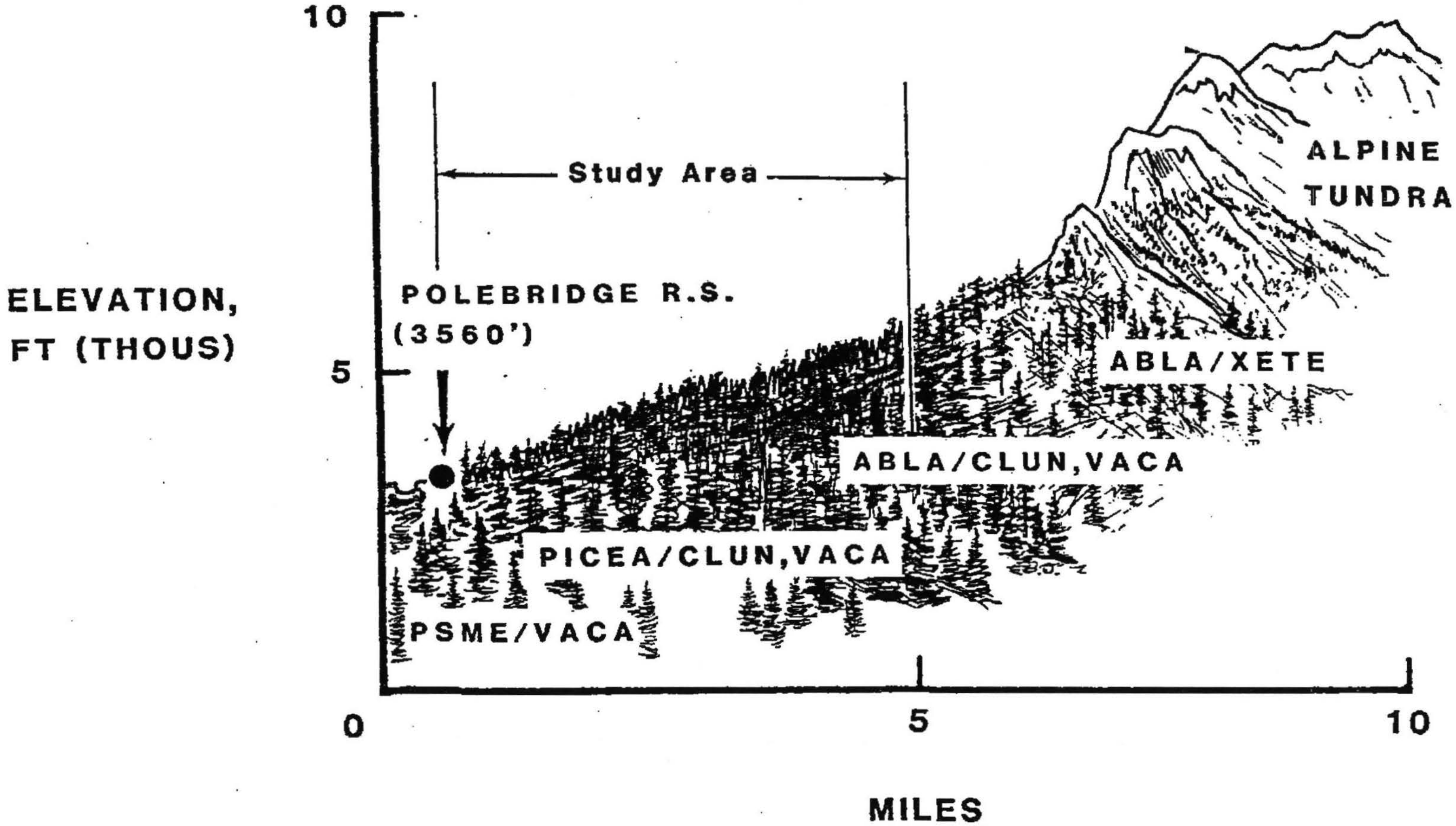
The North Fork is a large glacial valley, with GNP occupying the east half and the Flathead National Forest and private inholdings on the west. Lateral moraines from past mountain glaciers extend down into the valley from the craggy Livingston Range to the east, and these moraines form a rather gentle topographic relief throughout the study area. Elevations range from 3500 feet (1067 m.) along the river, to over 10,000 feet (3049 m.) at the crest of the Livingston Range. The study area, however, generally does not exceed 5000 feet (1524 m.); research was concentrated on the lower-elevation forests because planners are now focusing on this portion of the natural fire zone, and, difficult access to the remote backcountry was a limiting factor.

The valley is densely forested, with seral lodgepole pine the predominant type below 5000 feet (1524 m.), usually less than 150 years old before beetle mortality. In fact, there are few near-climax stands in entire valley, a result of relatively recent, large fires. The main exception is in some of the area's moderate amount of Douglas-fir (Pseudotsuga menziesii)/western larch (Larix occidentalis) benchland stands, which are from 350-500 years old and often are dominated by climax Douglas-fir and spruce (Picea engelmannii x glauca)(Habeck and Weaver 1969). The area also has some relatively old riparian communities, dominated by spruce and black cottonwood (Populus trichocarpa), with the spruce up to 250-300 years old. A few tiny groves of aspen (Populous tremuloides), less than 100 years old, are found in the lower elevations and these stands are not regenerating

because of fire's absence. Ponderosa pine (Pinus ponderosa), usually 200-600 years old, is restricted to about 7500 acres (3036 ha.) in the North Fork valley and these stands also have had little regeneration in this century (Lunan 1972). The ponderosa pine stands usually are confined to dry benchlands below 4000 feet (1220 m.), and represent a disjunct northeastern extension of the species' range in the United States (Habeck 1970). Finally, several small inclusions of Palouse Prairie grasslands represent another unusual community type in the North Fork (Koterba and Habeck 1970). These occupy less than about 2500 acres (1012 ha.) and are dominated by bunchgrasses and big sagebrush (Artemesia tridentata).

There is an overall lack of diversity among the study area's forest habitat types. Types range from cool-moist to cool-dry and key to either Douglas-fir, spruce, or subalpine fir (Abies lasiocarpa) as the potential climax trees (Pfister et al. 1977)(fig. 2). Understory unions usually key to either relatively dry dwarf huckleberry (Vaccinium caespitosum) or moist clintonia (Clintonia uniflora) in the lower elevations, or beargrass (Xerophyllum tenax) in the upper elevations.

Figure 2. North Fork valley cross-section and habitat types (abbreviations follow Pfister et al. 1977).



METHODS

The methods of Arno and Sneck (1977) were used to document fire history. Twenty transects were established along roads and trails throughout the study area, ultimately resulting in about 76 miles (122 km.) of linear sampling (fig. 3). A chainsaw was used to collect clustered fire scar samples; partial cross-sections were removed from old-growth trees, and no live trees were felled. Fire scarred trees also were sampled at 5 locations across the valley on national forest land, 1-3 miles (1.6-5 km.) due west. Finally, an increment borer was used to obtain representative samples from fire-initiated age classes along the transects. The following criteria had to met in order for increment core samples to be considered representative of a fire-initiated age class (Arno and Sneck 1977): (1) large numbers of early-seral trees had to be present in the stand, (2) the piths of each apparent age class, cored at a height of one foot (30 cm.), had to date within 10 years of an area fire scar date, if available, and (3) at least 3 of these closely-similar pith dates had to be obtained from the trees.

Circular 375m2 habitat type plots were established at representative locations along the transects (Pfister and Arno 1980); stand succession was documented in these 54 plots by recording canopy coverage of each tree and undergrowth species, tree d.b.h. classes, and tree age classes. Downed woody fuels also were photographed at each plot, and general fuel appraisals were later made using Fischer's (1981 a & b) photo guide series.

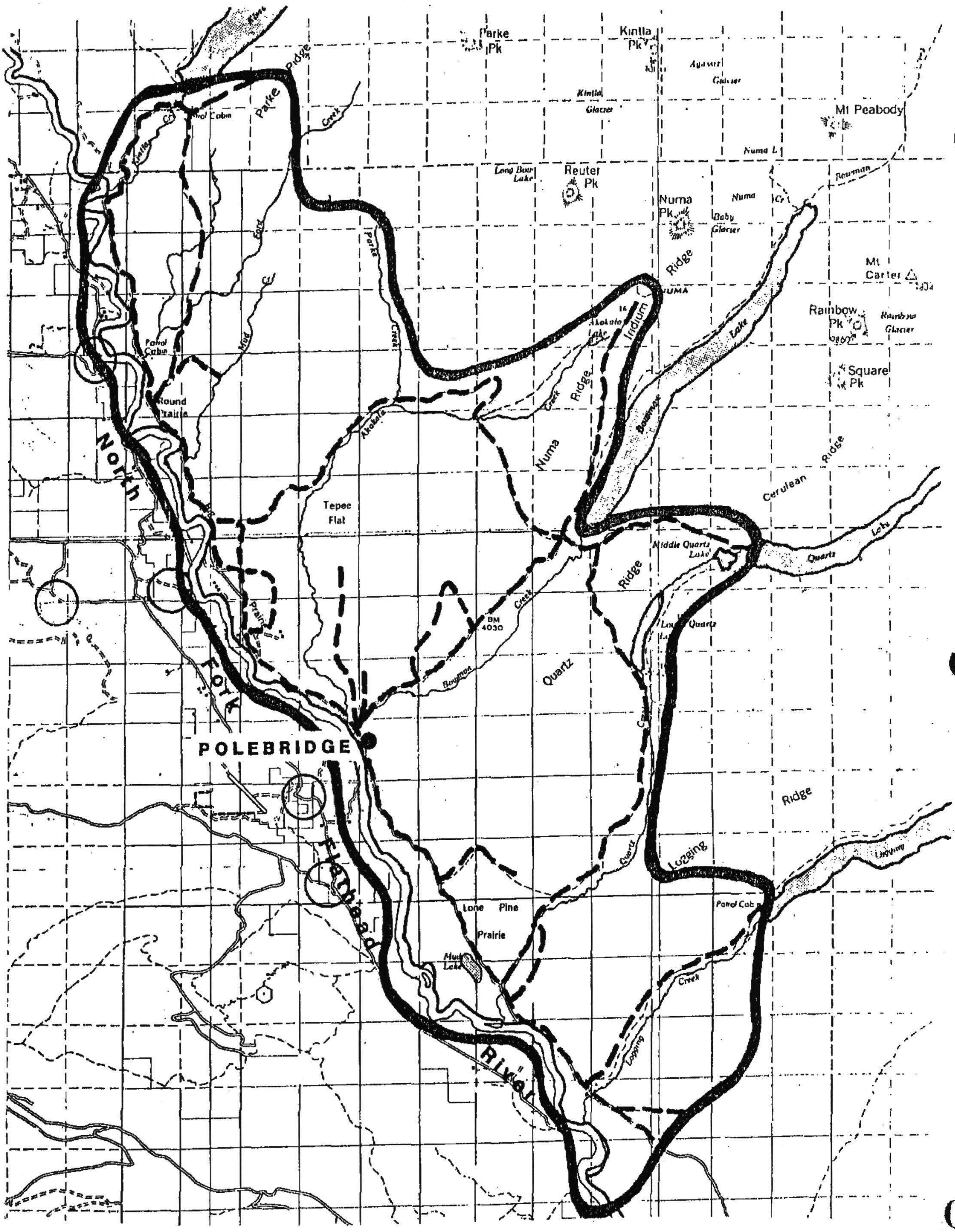


Figure 3. Study area and sample transects. Circles indicate sample locations on the Flathead National Forest.

The fire scar samples and increment cores were air-dried in a laboratory, followed by sanding to a smooth polish. A binocular microscope (7x to 30x) was then used to make ring counts, for a preliminary dating of the fire scars and increment cores. Next, Master Fire Chronologies were constructed for the entire study area, for the study area's 4 major drainages, and for 20 small sample stands of less than 100 acres (40 ha.) each. The Master Fire Chronologies were developed by, first, subjectively determining the relatively continuous period of fire record in a given land unit. The next step was to estimate the fire years in the chronologies by adjusting fire scar dates, usually within a range of 5 years among close-by samples. In a few cases, pith dates alone had to be relied upon to derive rough estimates of the fire years. The method here was to subtract 10 years from the earliest date of a group of similarly aged pith samples; the 10 years were felt to be a reasonable estimate for the length of time required for post-fire seedling establishment and growth to the one foot (30 cm.) coring height.

The next step was to estimate fire frequencies for the various land units (i.e., for the study area, for the 4 drainages, and for 20 small stands). This was done by calculating mean fire intervals (MFIs), or the average number of years between consecutive fires (MFI = total years in a Master Fire Chronology divided by the number of fire intervals).

Finally, small-scale fire maps (1:126,720) were developed by: (1) coordinating the adjusted fire scar dates with their field locations (these were marked in the field on 7.5 minute

topographicmaps), (2) identifying fire-initiated stands by tracing the increment core dates to the cores' field locations, and by (3) using the results of aerial photograph interpretation (pers. comm. with GNP Plant Ecologist C. Key) to delineate the extent of the fire-initiated age classes.

RESULTS AND DISCUSSION

The field sampling produced 272 partial cross sections from fire scarred trees. Additionally, estimates for 337 tree pith dates were obtained from increment cores and from many of the partial cross sections; most of these pith dates were from seral lodgepole pine, western larch, or ponderosa pine, representing the various fire-initiated age classes.

Adjustment of fire scar dates was especially necessary in this study, for 2 reasons. First, the mountain pine beetle epidemic made it difficult to estimate the cambium years of recently killed lodgepole pines. Second, missing rings apparently are common in this area, especially on fire-scarred larch.

Eighty-one percent of the 272 fire scar samples had from 1 to 3 fire scars each. In terms of lodgepole pine's ability to survive surface fires, 98% of the 76 samples obtained from this species had 1 or 2 fire scars each; only 2 lodgepole pines were found with 3 fire scars. Nineteen percent of the 272 samples had 4 to as many as 7 scars each, and these were all on old growth ponderosa pine and larch.

One ponderosa pine sample is especially noteworthy. The tree, which was killed by mountain pine beetles in about 1980, is only about 15 inches (38 cm.) d.b.h., yet the pith rough-dated to about 1258 A.D..These approximately 722 years represent one of the oldest ponderosa pines yet found in the intermountain region.

Study Area Fire History

The North Fork fire chronology was extended back 500 years to about the 1470s, and the samples revealed 66 fire years during this time (Appendix). This approximately 1470 fire date represents the sole exception to the criteria that were established for sampling fire-initiated age classes; in order to obtain a rough estimate of the decade of the fire, it was necessary to rely on one pith date from a representative tree. The large diameter of this stand's old growth larch precluded the possibility of obtaining duplicate samples with a 20-inch (51 cm.) increment borer (the single pith date was obtained from a chainsawed fire scar sample).

The Master Fire Chronology for the study area spans 271 years, from 1655 to 1926, or, that period when the fire record seems to be relatively complete. The evidence becomes too fragmentary before 1655. Likewise, the data decreases markedly after about 1930, when efficient fire suppression began (Singer 1975). Fifty-five fire years were identified in the 271 year period from 1655-1926, for an overall MFI of 5 years. That is, a fire occurred somewhere in the 60,000 acre (24,292 ha.) study area at least every 5 years, regardless of fire size. This

undoubtedly is a conservative estimate of fire occurrence for the study area since this sampling approach would not allow detection of every spot fire over a 3-century span.

Fire size classes were defined in this study, to examine the areal extent of past burns. The 4 size classes are: (1) less than 50 acres (20 ha.), (2) 50-1000 acres (20-405 ha.), (3) 1000-10,000 acres (405-4049ha.), and (4) greater than 10,000 acres (4049+ ha.). Resultant MFIs for the larger fires are as follows. About 11 class 2 fires occurred, for an approximate MFI of 27 years. About 13 class 3 fires occurred, for an approximate MFI of 23 years. Eight fires exceeded 10,000 acres (4049 ha.), for an MFI of about 39 years. This short MFI for the very large fires can be somewhat misleading, however, because there was a skewed distribution in their occurrence over time; the mean was substantially shortened by a pulse of large fires between the mid 1800s and early 1900s (fig. 4). Overall, however, fires clearly were frequent and often extensive in the North Fork over the past 3 centuries.

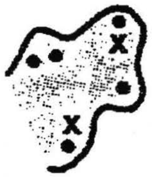
Three large stand-replacing fires apparently burned most of the study area in the 28 year period from 1655-1683 (figs. 5,6,7). Much of the upper North Fork valley probably also burned during this period, judging from the widespread locations of fire scars and stand-regeneration dates. In fact, 6 of the 12 samples cut on the other side of the valley also had fire scars or pith dates attributable to these fires. Many of the valley's current old growth larch germinated during this period.

Figures 5-10. Fire maps.

Key:

● : Fire scar sample.

x : Pith sample from fire-initiated age class.

 : Estimated fire margin; based on sample locations, aerial photographs, and fire atlas.

 : Fire margin unknown; minimum spread based on sample locations in conjunction with most logical topographic pathway.

 : Possible spot fire.

Figure 4. Study area fire history, 1655-~~1683~~ 1983 (fires smaller than 50 acres each not shown). Dashed lines indicate uncertain acreage estimates.

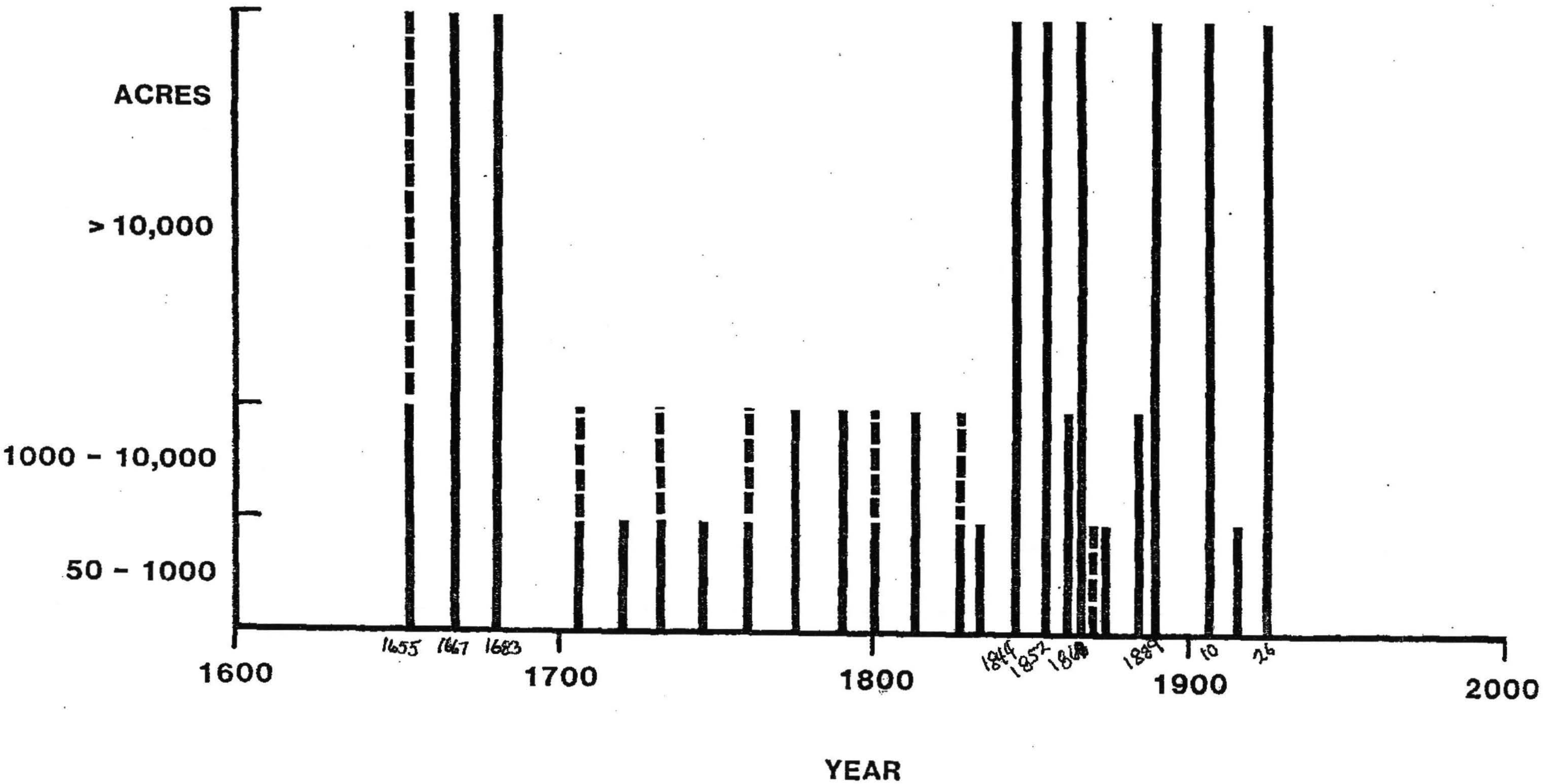
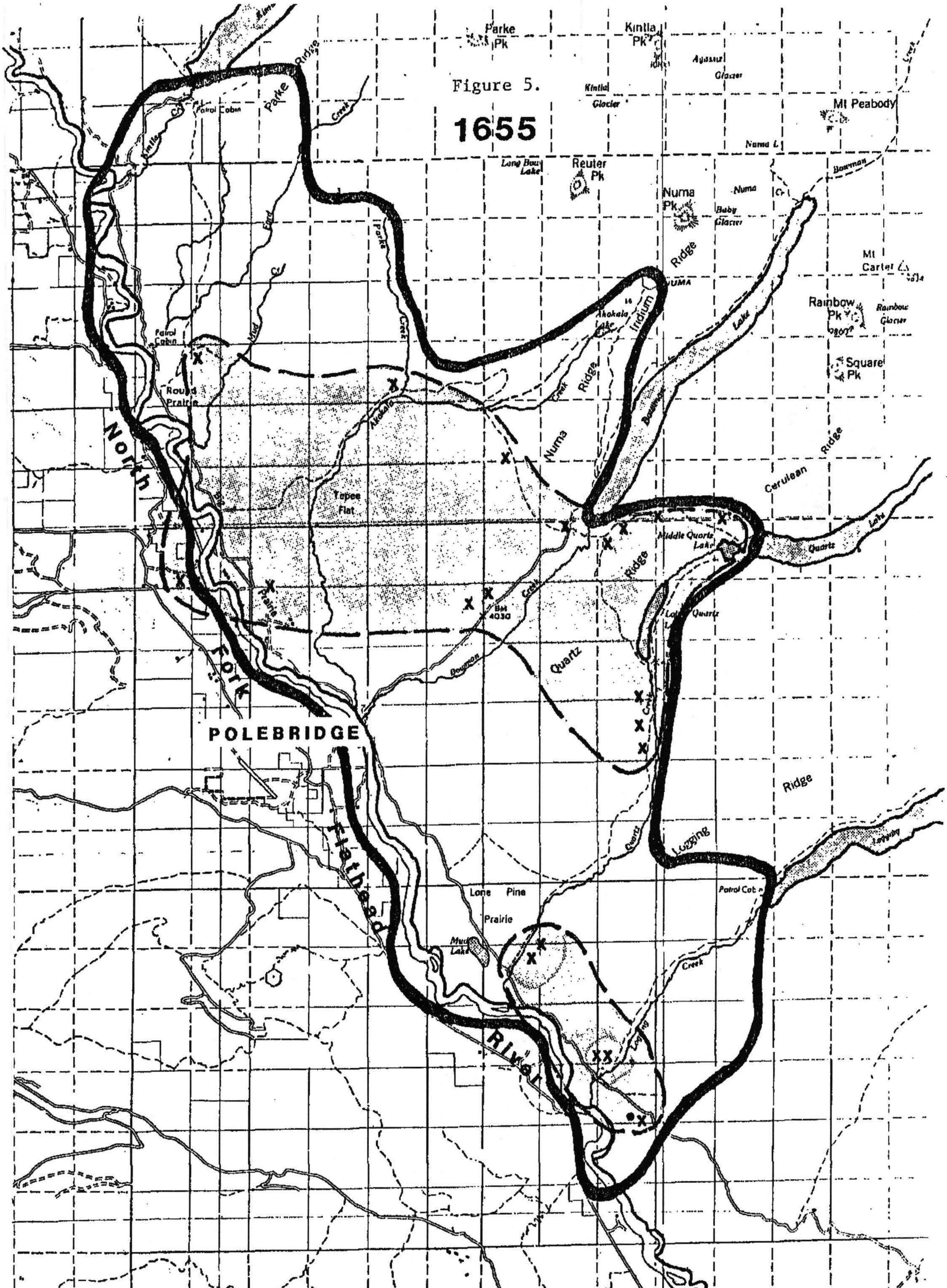


Figure 5.

1655



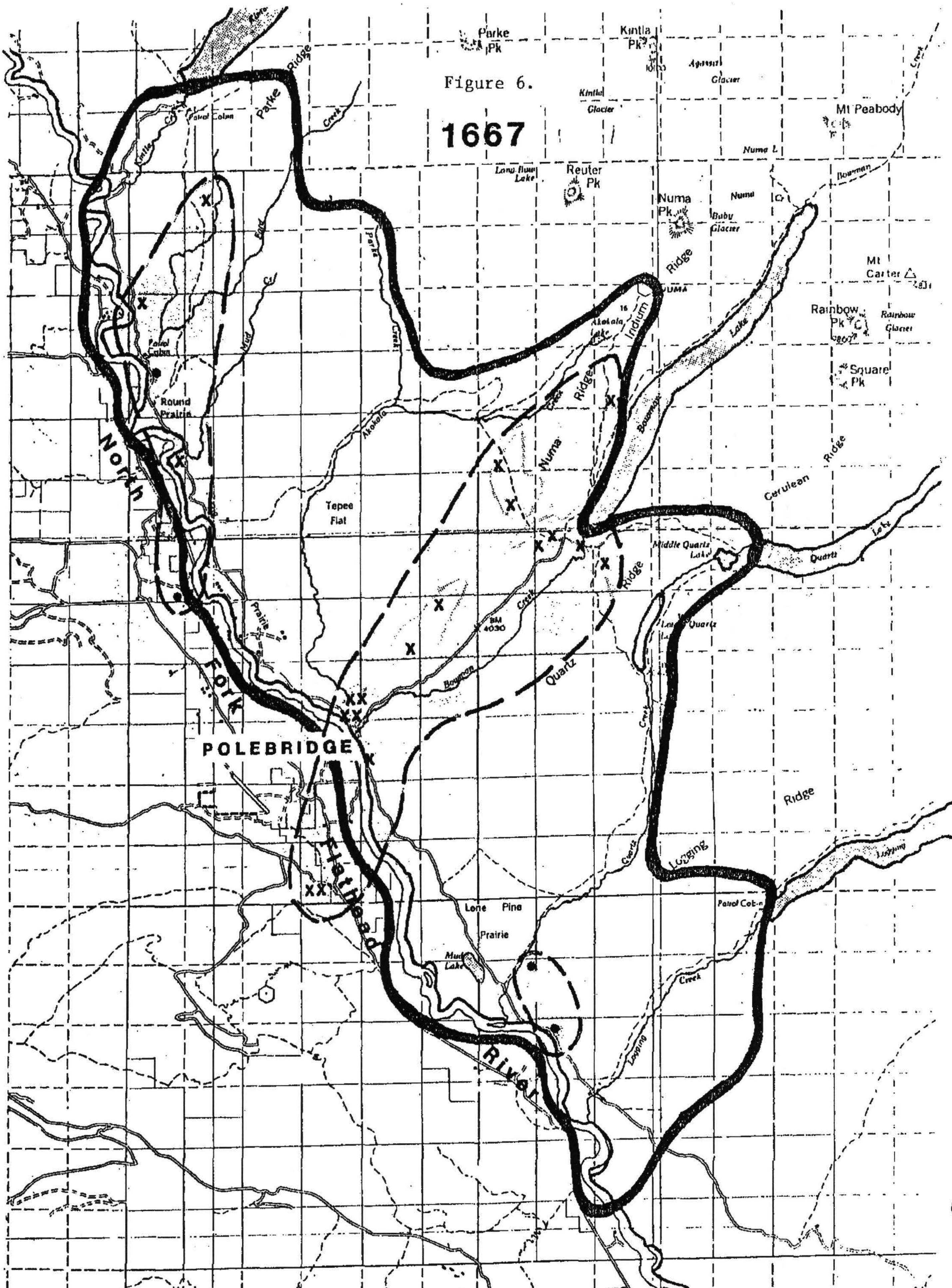

1667
Parke Pk
Kintla Pk
Agassiz Glacier
Kintla Glacier
Mt Peabody
Numa L
Long Bow Lake
Reuter Pk
Numa Pk
Numa
Baby Glacier
Bowman
Mt Carter
Rainbow Pk
Rainbow Glacier
Square Pk
Parke Ridge
Patrol Cabin
Kintla Cr
Creek
Parke Creek
Mud Cr
Patrol Cabin
Round Prairie
Akokala Lake
Akokala
Indium
Ridge
Numa Ridge
Bowman Lake
Cerulean Ridge
Quartz Lake
Middle Quartz Lake
Tepee Flat
Ridge
Quartz Ridge
Bowman Creek
BM 4030
North Fork
Flathead
River
POLEBRIDGE
Logging Ridge
Logging
Patrol Cabin
Lone Pine Prairie
Mud Lake
Logging Creek
Quartz Creek

Figure 6.

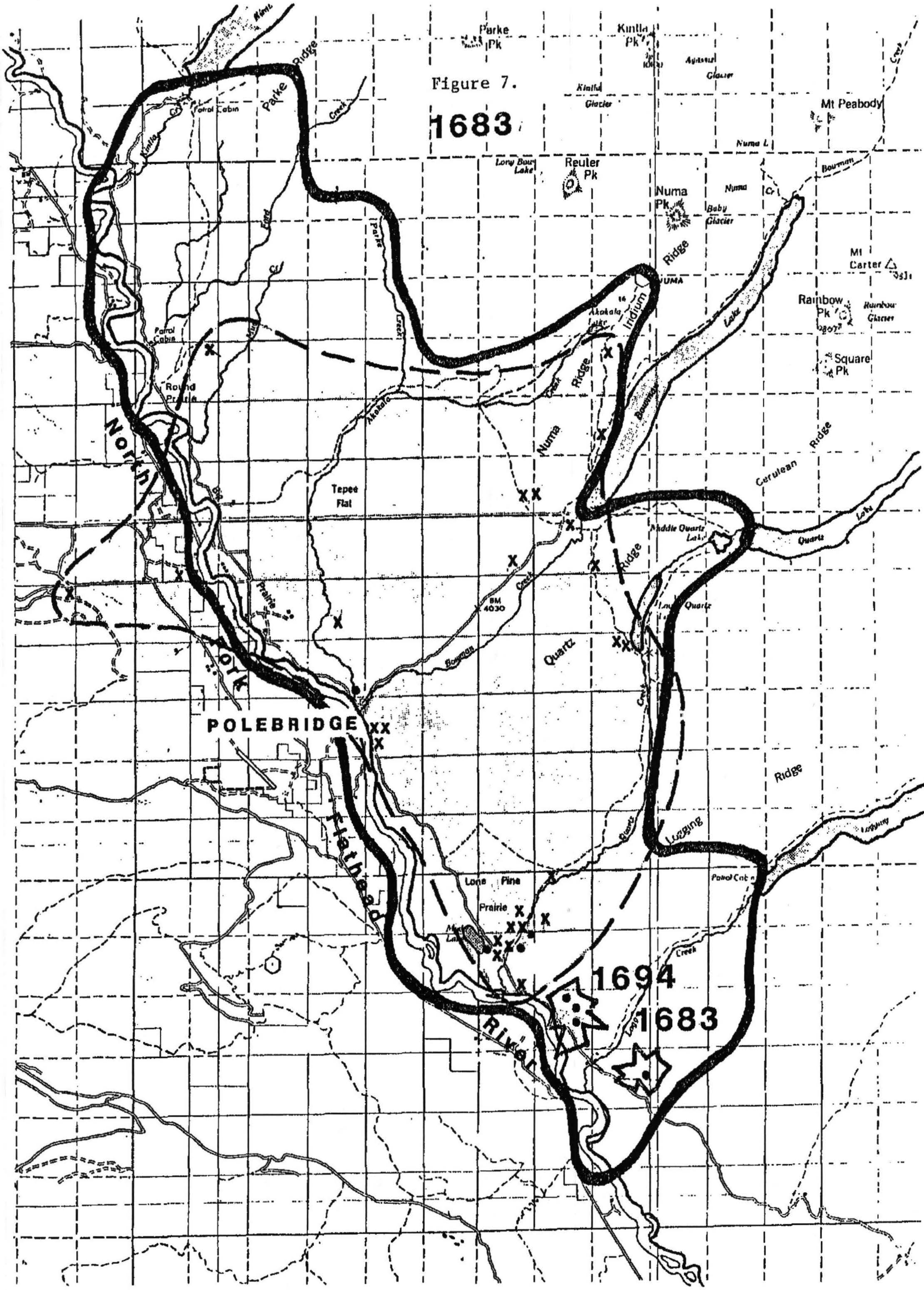


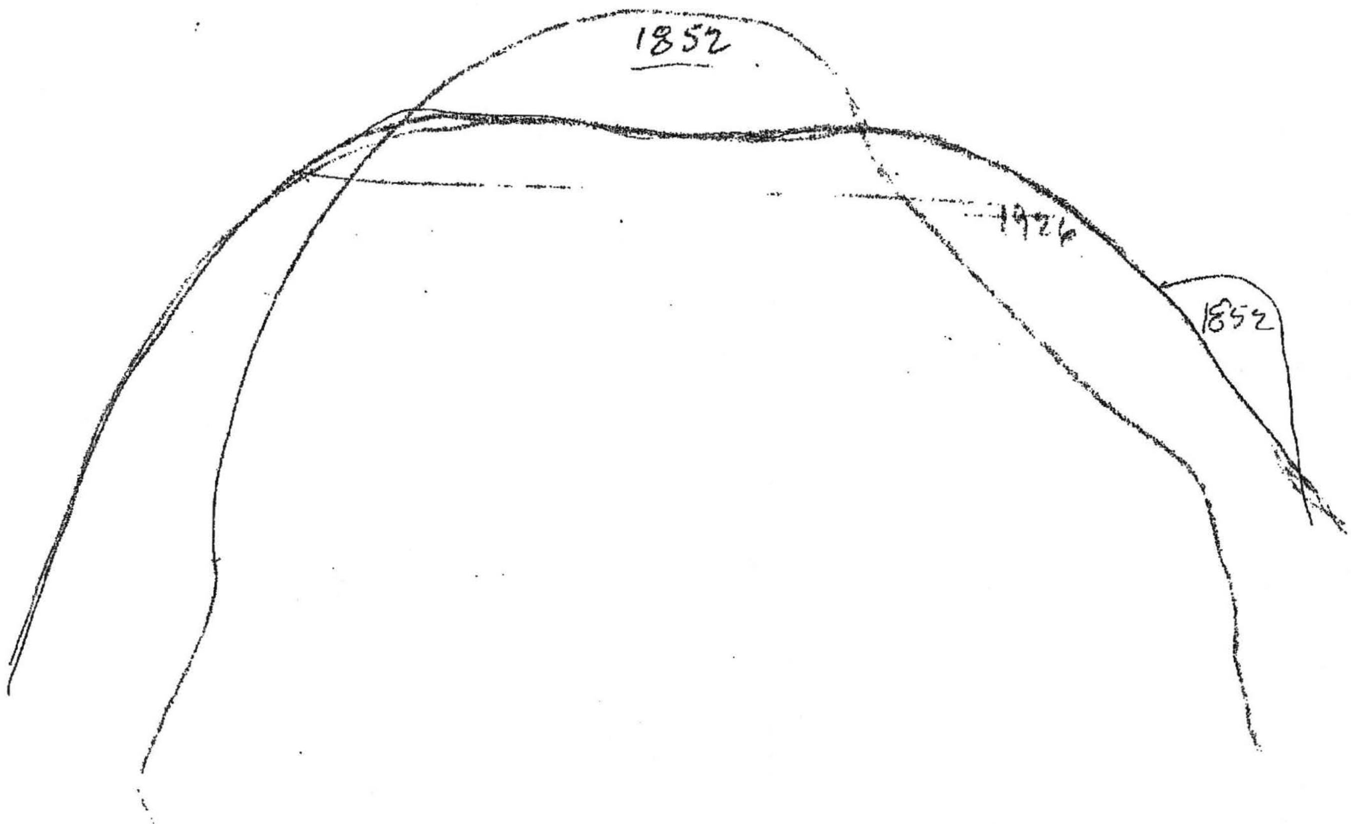
Figure 7.
1683
Parke Pk
Kintla Pk
Agassiz Glacier
Kintla Glacier
Mt Peabody
Numa L
Long Bow Lake
Reuter Pk
Numa Pk
Baby Glacier
Mt Carter
Rainbow Pk
Rainbow Glacier
Square Pk
Parke Ridge
Patrol Cabin
Patrol Cabin
Round Prairie
North Fork
Akokala Lake
Akokala Creek
Numa Ridge
Tepee Flat
Cerulean Ridge
Middle Quartz Lake
Quartz Lake
Quartz Ridge
BM 4030
Bowman
POLEBRIDGE
Flathead River
Lone Pine Prairie
Logging
Logging
Patrol Cabin
Ridge
1694
1683

The next major stand-replacing fire occurred 161 years later in 1844. During this 161 year period, most of the fires documented were either largely underburns, or just smaller stand-replacing fires of less than 1000 acres (405 ha.) each (Appendix). (As differentiated from "stand-replacing" fires, "underburns" here refer to predominantly surface fires which do not spread into and destroy tree crowns over contiguous areas). The pith data show few age classes attributable to fires during this 161 year period between 1683-1844.

Like others who have studied fire history in this region (Singer 1975, Arno 1976, Sneck 1977, Tande 1977), I found an increase in the frequency of large fires between the mid 1800s and early 1900s. The fire maps suggest that nearly 90% of the study area burned in the 39 years from 1887 to 1926. Particularly remarkable are the large fires of 1889, 1910, and 1926 (figs. 8,9,10), which each burned tens of thousands of acres or more. Other fire history studies (cf. Arno 1980, Barrett 1982) indicate that 1889 and 1910 also were severe fire years in many other areas of the Northern Rockies.

The valley's 6 major lodgepole pine age classes thus originated after the very large fires of 1844, 1852, 1866, 1889, 1910, and 1926 (fig. 11). In the study area itself, however, many acres of underburns resulted during this period of extensive fires. Results from aerial photograph interpretation (pers. comm. with GNP Plant Ecologist C. Key) suggest that, with each successive fire after the large ones of 1844, 1852, and 1866, often only small areas of even-aged regeneration ~~resulted~~ remained within

the study area. Many of these patchy smaller stands are less



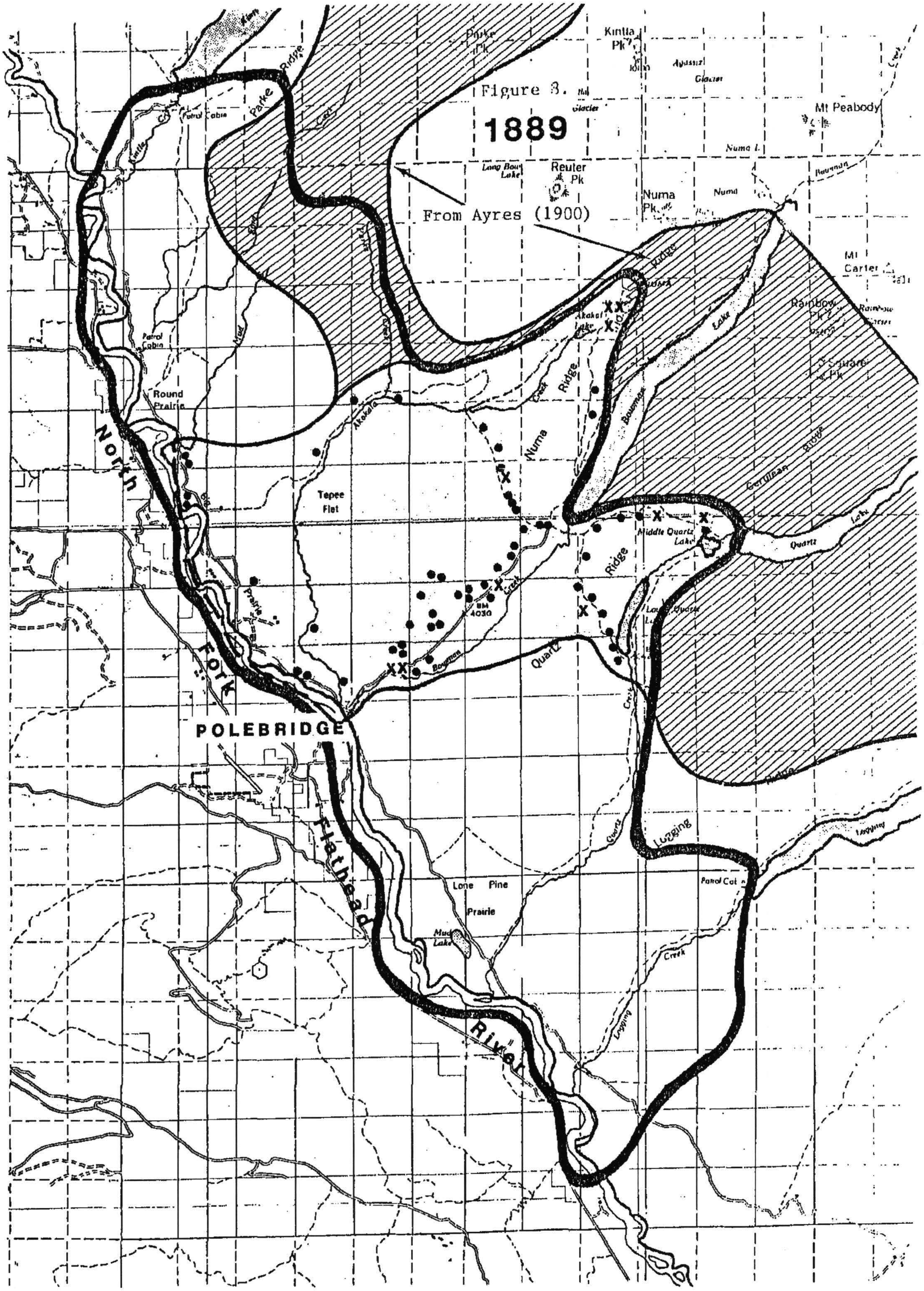


Figure 3.
1889
From Ayres (1900)
Kintla Pk
Parke Pk
Parke Ridge
Mt Peabody
Reuter Pk
Numa Pk
Long Bow Lake
Mt Carter
Rainbow Pk
Square Pk
Patrol Cabin
Round Prairie
Tepee Flat
Numa Ridge
Akokala Creek
Bowman Lake
Cerulean Ridge
Quartz Creek
Middle Quartz Lake
Lower Quartz Lake
BM 4030
POLEBRIDGE
North Fork Flathead River
Logging Creek
Patrol Cab
Lone Pine Prairie
Mud Lake

Figure 9.

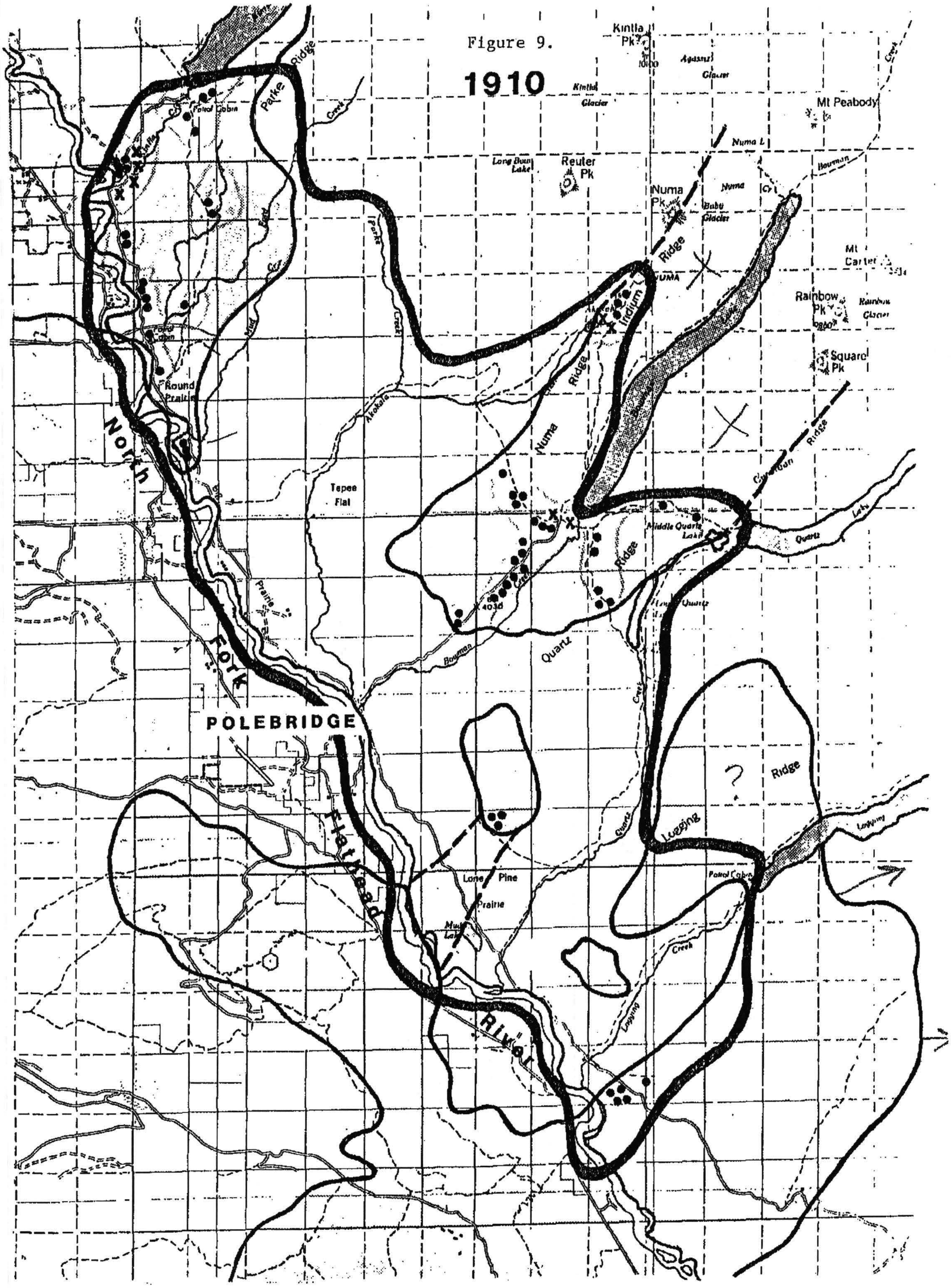
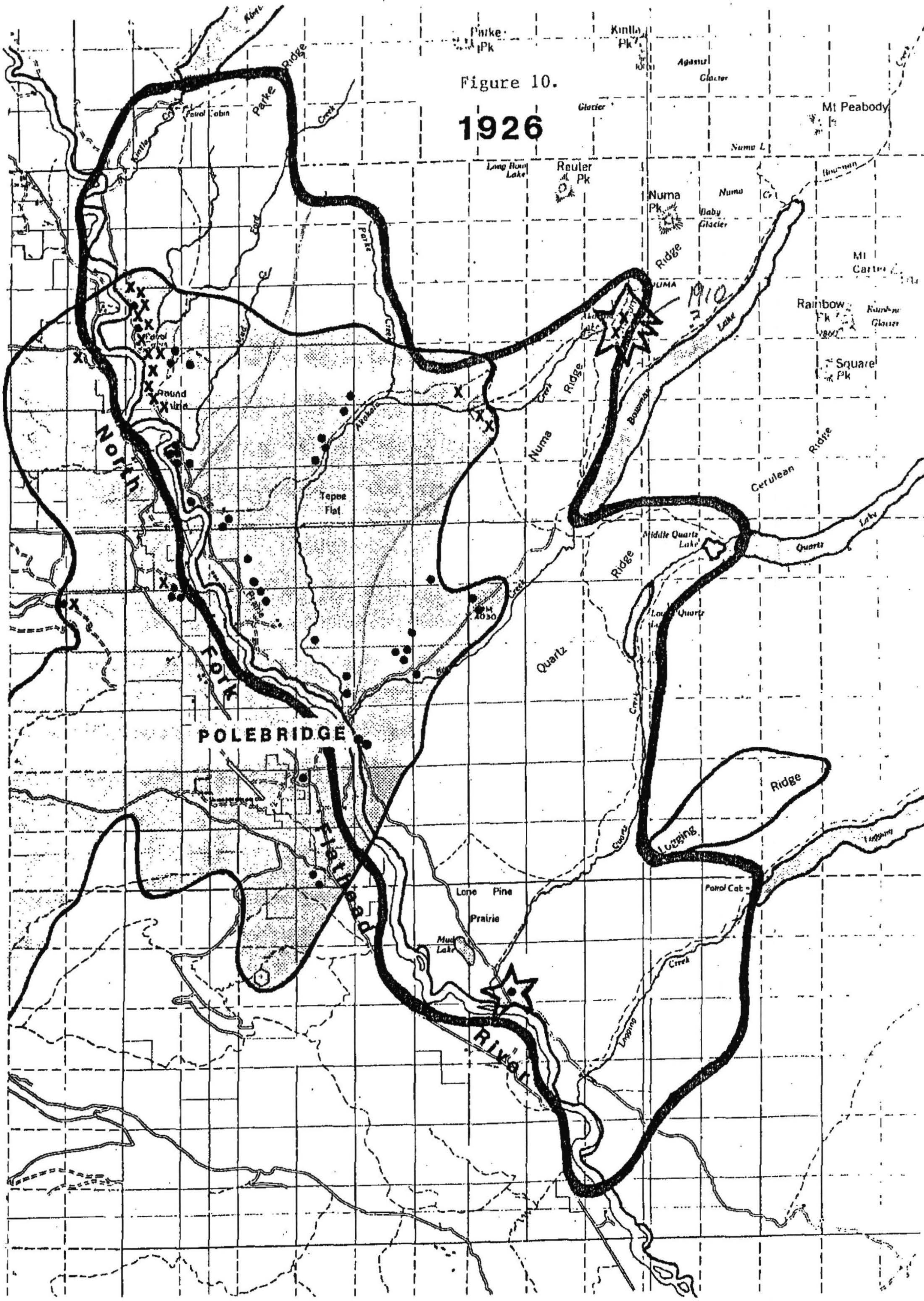

1910
Kintla Pk
Agassiz Glacier
Kintla Glacier
Mt Peabody
Numa L
Long Bow Lake
Reuter Pk
Numa Pk
Baby Glacier
Mt Carter
Rainbow Pk
Rainbow Glacier
Square Pk
Parke Ridge
Patrol Cabin
Round Prairie
North Fork
Flathead
River
Numa Ridge
Indium
Tepee Flat
Middle Quartz Lake
Quartz
Ridge
Bowman
POLEBRIDGE
Lone Pine Prairie
Logging Ridge
Logging Creek
Patrol Cabin
?

Figure 10.


1926
Parke Pk
Kintla Pk
Agassiz Glacier
Glacier
Mt Peabody
Numa L
Long Bow Lake
Reuter Pk
Numa Pk
Numa
Baby Glacier
Ridge
Mt Carter
1910
Rainbow Pk
Rainbow Glacier
Square Pk
Parke Ridge
Creek
Patrol Cabin
Round Prairie
North Fork
Akokala
Tepee Flat
Numa Ridge
Cerulean Ridge
Middle Quartz Lake
Quartz
Ridge
Lower Quartz
Quartz Creek
POLEBRIDGE
Flathead
River
Lone Pine Prairie
Mud Lake
Ridge
Logging
Patrol Cab
Logging Creek

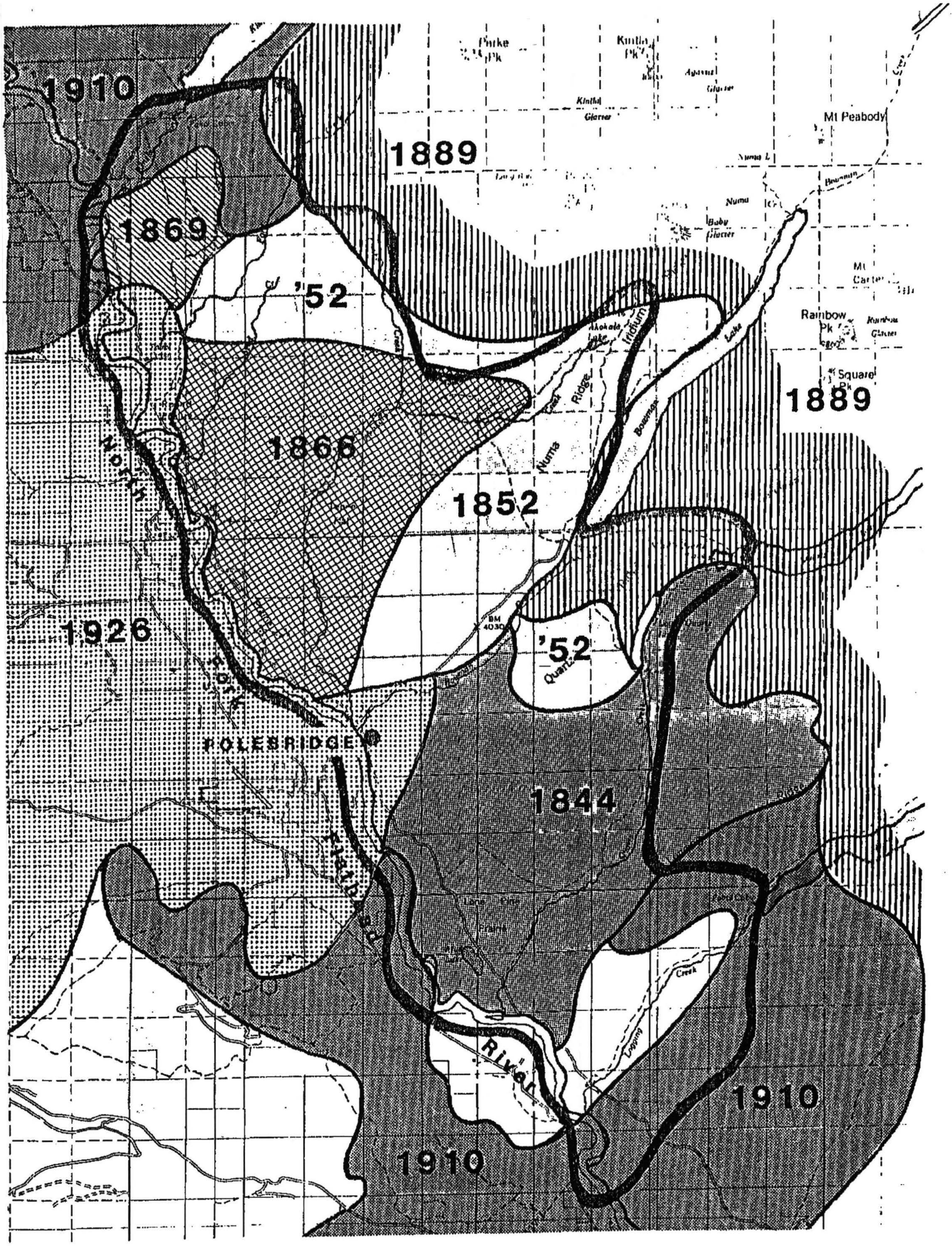


Figure 11. The upper North Fork valley's 6 major lodgepole pine age classes: 1844, 1852, 1866, 1889, 1910, 1926.

than 1000 acres (405 ha.) each. Conversely, the steeper upper slopes just east of the study area show the most evidence of more-recent stand replacement, largely in 1889 and 1910, 1926 This burning pattern was first described by Ayres (1900), evidently after witnessing the aftermath of the very large 1889 fire:

> "Near the mountains [rising east out of the study area], and especially upon their lower [subalpine] slopes, fires have been so severe that very few trees are left, and the whole western side of the mountain range, as seen from a distance, appears brown and barren." (Ayres 1900: 257).

However, the same fire left numerous fire scars in lodgepole stands nearly all the way to the river bottom, indicating the study area's frequent tendency to underburn, sometimes quite extensively. For example, my 1889 fire map suggests that this fire, which evidently exceeded 100,000 acres (40,486 ha.) in GNP, underburned as many as 15,000 acres (6073 ha.) in my sample area alone. (Ayres' early fire map does not specifically indicate that it represents the 1889 fire, but it was the sole fire of that size around that time; his map has thus been incorporated into my 1889 fire map [fig. 8]). Another example of extensive underburning is provided by the widespread 1910 fires, which probably were comparable to the 1889 fire in terms of total acres burned. The 1910 fires resulted in many acres of stand replacement on both sides of the North Fork valley, but as many as 10,000 acres (4049 ha.) were underburned in the study area's lodgepole pine forests (figs. 9 and 11).

The 12 samples that were obtained across the valley on national forest land revealed 13 fires from 1655-1926; 8 of these also scarred sample trees in the park and 5 were major fires (figs. 5,6,7,9,10; Appendix). These fires probably either originated outside the park, upwind, or perhaps were ignited during the same lightning storm. The prevailing southwesterly winds that sweep down out of the adjacent Whitefish Range probably would have pushed most developing fires east across the river, onto GNP land. Supporting evidence for this hypothesis is supplied by the GNP fire atlas, which shows that 4 such fires burned into the park between 1910-1929 alone (no fires have crossed the river from the park's side over the past 72 years of record-keeping). 1926, 1967

Lightning probably was the cause of most fires before 1900, because human activities were very limited in the North Fork valley. The archaeology of GNP's west side is fragmentary, but Indian use evidently was sparse and limited to small hunting parties (Malouf 1965). Deliberate burning for subsistence purposes (Barrett 1981) probably would have been of limited value in this area; the small grassland prairies may have been burned occasionally to improve forage, but the extensive lightning fires in the surrounding forests probably were frequent enough to not require human ignitions.

There is some evidence that humans contributed to fire's increase during the late 1800s (Ayres 1900), but this one source may not be totally reliable. Ayres conducted an early forest survey of the North Fork valley and surrounding areas, and he

concluded that careless travelers, hunters, and prospectors were the main causes of fires. Unfortunately, authors of the early Forest Reserve reports usually did not recognize that lightning was a frequent ignitor, so fires almost always were attributed to humans.

The bulk of evidence supports the hypothesis that lightning was the principal fire source in the North Fork, at least since the mid-1800s. The regional agreement of fire history data, interpretations from a GNP glacial-retreat study (Carrara and McGimsey 1981), and regional dendroclimatological data (Keene 1937, Laephart and Stage 1968) all suggest that several severe droughts occurred between about 1840 and 1935. Thus, there probably was increased opportunity for the area's frequent lightning ignitions.

The GNP fire atlas provides a reliable record of more-recent man-caused fires in the park. For example, 3 large man-caused fires, in 1910, 1917, and 1926, collectively burned about 22,260 acres (9012 ha.) of the study area. (Park-wide, more than 125,000 acres [50,607 ha.] have been burned by man-caused fires since record-keeping began in 1910).

The 1926 fires, some also caused by lightning, were the last large ones in the study area. During this fire season about 40,000 acres (16,194 ha.) burned on both sides of the North Fork valley, based on estimates from the early GNP and Flathead National Forest fire maps. Subsequently, my 272 sample trees have recorded only 3 spot fires over the past 56 years.

Ninety lightning ignitions occurred in or immediately

adjacent to the study area during this period of efficient fire suppression (fig. 12).

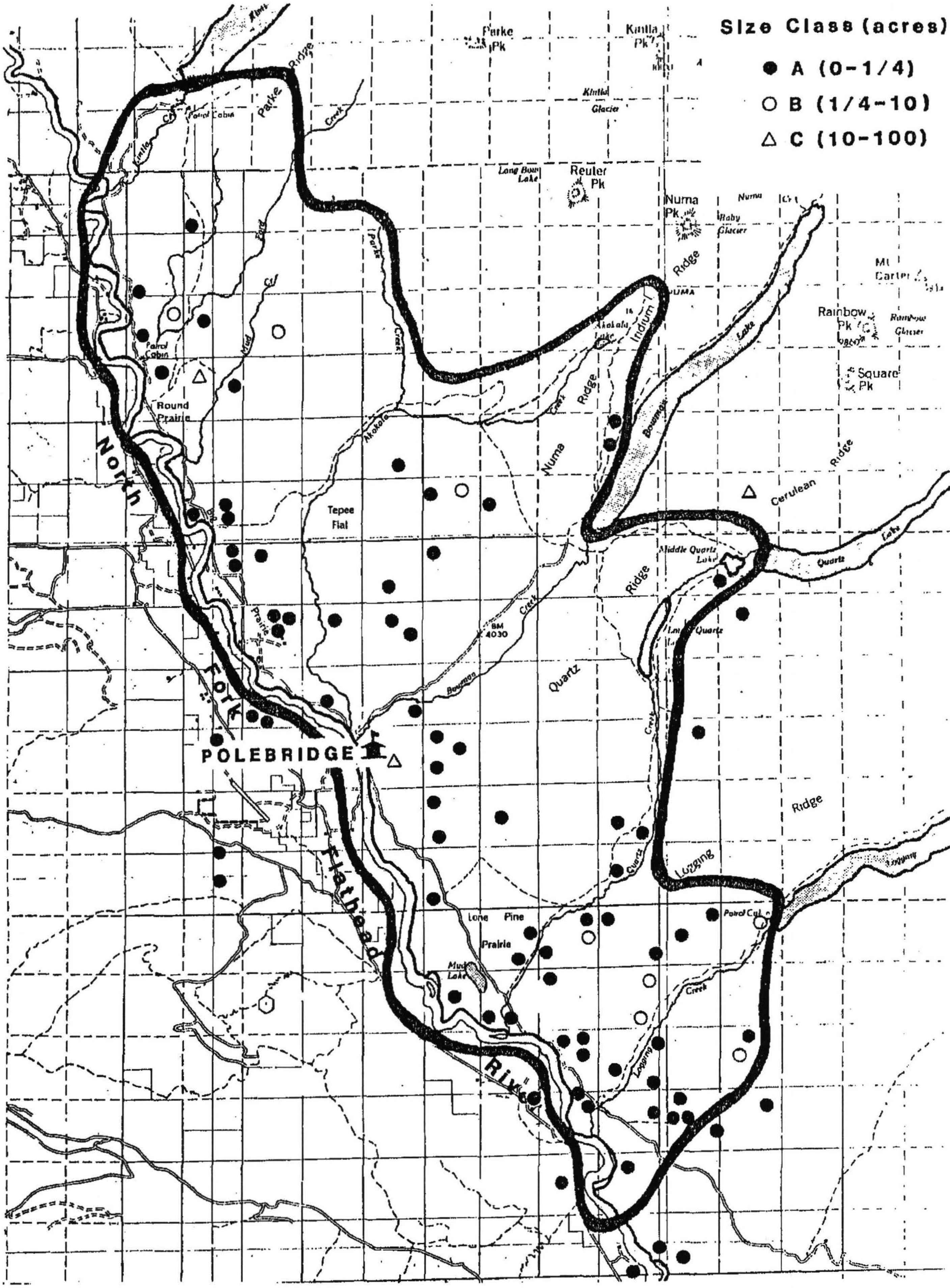


Figure 12. Lightning fire distribution, 1930-1982.

Nearly 90% of the ignitions, however, were suppressed before exceeding 1/4 acre (.1 ha.). At most, 297 acres (120 ha.) have burned in this area since 1930, and this undoubtedly is a substantial over-estimate. This estimate was derived simply by totalling the maximum number of acres possible per fire size class in the area since 1930 (i.e., classes A, B, or C). (The Individual Fire Reports [Form 5100 series] sometimes do not list the precise number of acres burned before the fire was extinguished).

Some of these ignitions over the last 50 years might well have developed into fires of substantial acreage, had there been no suppression action. For example, one-third of the ignitions occurred in the 1930s, a decade of severe regional drought (Keene 1937, Laephart and Stage 1968). The GNP fire atlas shows that 1936 and 1937 were particularly active fire seasons. In 1940, 2 potentially large fires occurred just east of the study area in subalpine forests of lodgepole pine, subalpine fir, and whitebark pine. These fires both crowned and required large crews of 45 and 184 men each before being suppressed at less than 35 acres. During the well-known severe drought year of 1967 (Fischer 1969), which produced large fires elsewhere in GNP, fires near Polebridge Ranger Station and Round Prairie both crowned in very densely stocked stands of young lodgepole pine before being suppressed with the aid of a bulldozer. Consequently, there seems to be little doubt that fire suppression has interrupted the natural fire frequency in the North Fork valley.

Weather

Singer (1975) investigated fire history in a small portion

of the current study area and found suprisingly more-frequent fires during the post-1926 period. His work merits considerable discussion here. The study's goal was to examine fire history relative to ungulate habitat and his research focused on the lower-elevation benchlands, generally in the Douglas-fir/larch/ponderosa pine stands. His methods of estimating fire frequency are somewhat obscure; the study occurred before the development of a standard methodology (Arno and Sneck 1977). Still, his frequency estimates agree reasonably well with mine for the study area as a whole, and for small stands in the various forest types. Agreement in terms of specific fire years is not good, probably reflecting our different laboratory techniques. (Fire year agreement is not as important, however, as is agreement on the actual number of fires that occurred in the study area; both study's methods of estimating fire years are imprecise).

One problem is that Singer evidently did not adjust fire scar dates to arrive at a consensus date for a given fire (Arno and Sneck 1977); he often had different dates for adjacent samples apparently scarred in the same fire year. His findings thus probably include a few more fires than actually occurred. For example, his fire chronology lists a cluster of fires in 1925, 1926, 1928, and 1929. My data and the GNP fire atlas indicate that these undoubtedly represent the widespread 1926 fires. My more-numerous and more-widely distributed sample trees did not reveal any fires immediately before or after that year.

Such clustered dates in Singer's analysis apparently

resulted from a failure to account for dating problems, such as false or missing rings. Missing rings seem to be relatively common in this area, especially on western larch. I examined his stored fire scar samples and it appears that only rough ocular ring-counts were made directly off chainsawed samples, rather than using a microscope to examine smoothly-sanded wood surfaces. Logically, this approach would result in highly variable ring counts for the same scar year. I also cut 5 samples from Singer's sample-tree stumps, all ponderosa pine with up to 6 fire scars each. After sanding, ring counting, and adjusting the scar years among nearby sample trees, my fire year estimates differed from Singer's, sometimes by as many as 5 years. In 2 cases there also was a lack of agreement on the number of fire scars per sample, resulting in different estimates for the number of fires that occurred in the stand.

All of these problems evidently led to Singer's over-estimate of fire occurrence. This problem is particularly evident for the post-1900 era, largely during the period of efficient fire suppression. For example, his chronology lists 20 fires from 1904 to 1973. My more-numerous sample trees recorded only 8 fires during the same period, in a study area about 3 times larger. Written records also do not seem to bear out his findings. Although a substantial number of fires occurred during this time (fig. 12), most were spot fires of insufficient intensity and spread to scar trees. A final problem contributing to this apparent over-estimate is that Singer sometimes may have mis-identified fire scars. Examination of his raw data sheets

reveals that most of the questionnable post-1900 fires were obtained from solitary lodgepole pines, which are highly susceptible to mechanical scarring from such sources as blowdowns, mountain pine beetles (Stuart et al. 1983), or ungulate antler rubbings (Barrett 1982).

Drainage Fire History

Fire history was examined in large portions of the study area's 4 major creek drainages, or about 4000-7000 acres (1619-2834 ha.) of each area (fig. 13). The objectives were to examine the patterns of underburns and stand-replacing fires, in order to understand stand dynamics, and possibly shed light on the question of fire history's relationship to mountain pine beetle epidemics.

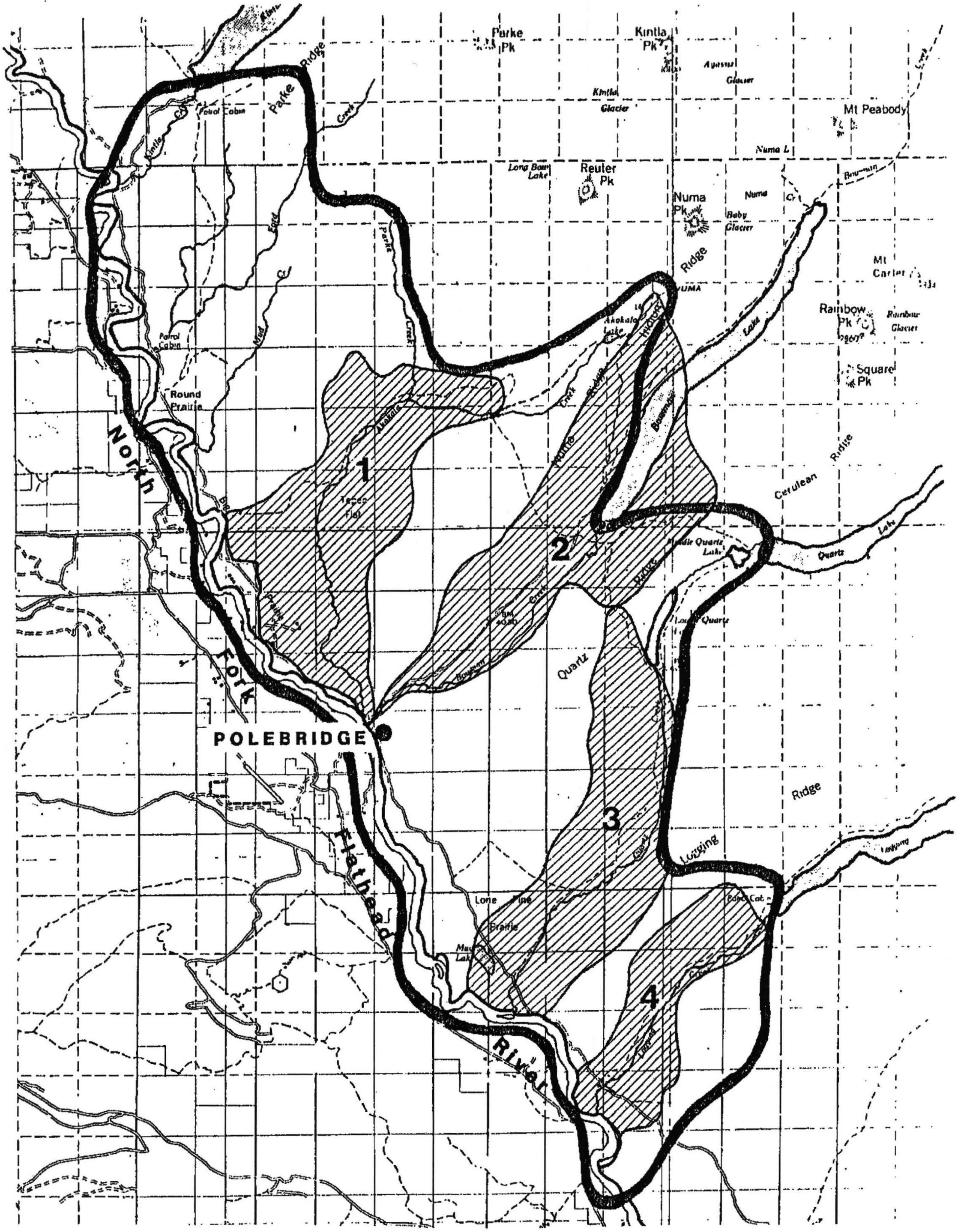


Figure 13. Drainage sample areas: (1) Akakola Cr., (2) Bowman Cr., (3) Quartz Cr., (4) Logging Cr.

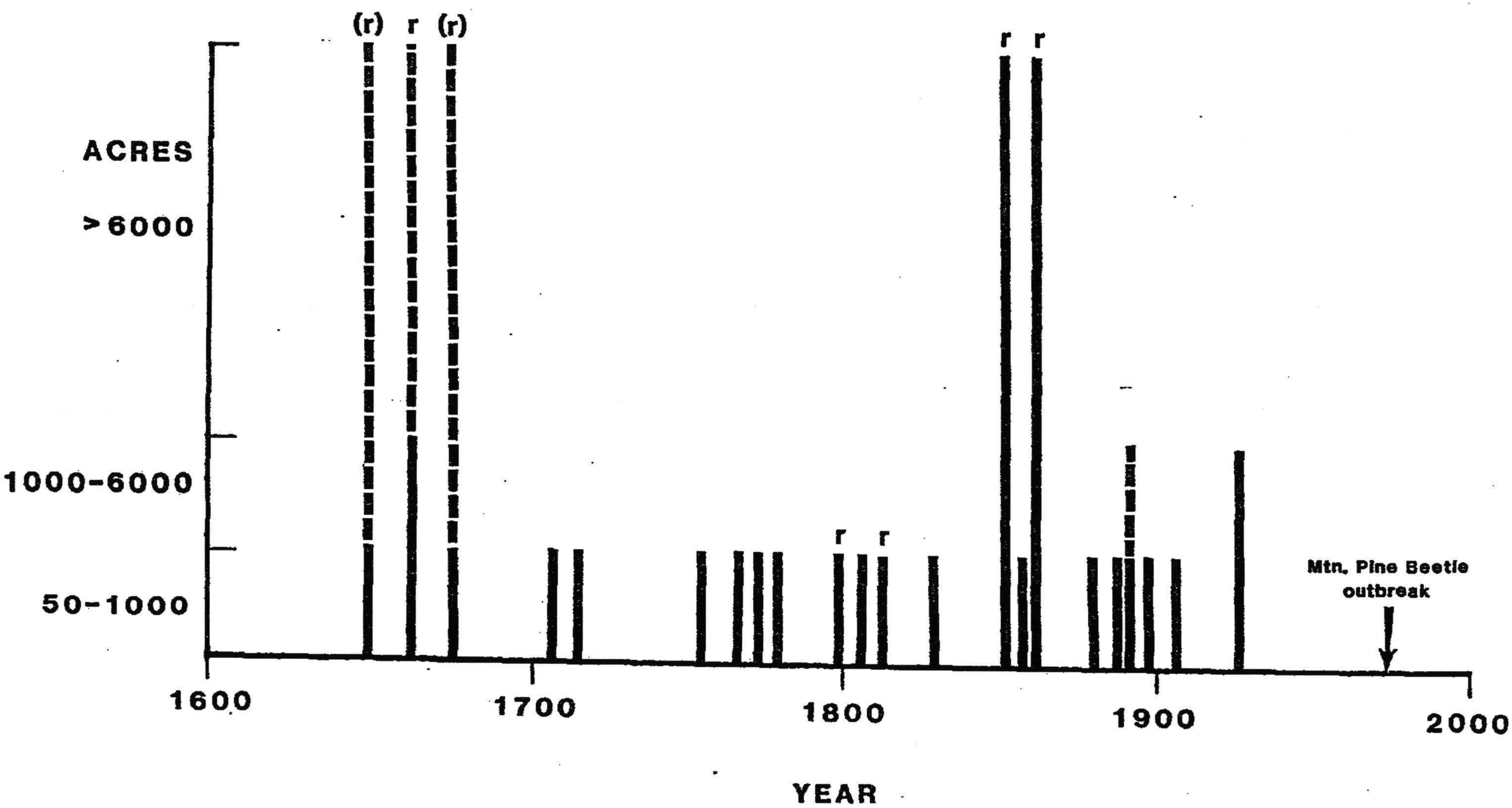
Akakola Creek. This sample area is about 7000 acres (2824 ha.)(fig. 13), with elevations ranging from 3640-4800 feet (1110-1463 m.). About 80% of the sample area is along the lower-slopes (Douglas-fir, spruce, or lower subalpine fir habitat types), with the remaining 20% in mid- to upper-slope stands (spruce and subalpine fir habitat types, primarily beargrass union).

Between 1655-1926, fires occurred at average intervals of about 13 years. This drainage had the shortest MFI of the 4 sample areas, possibly because of: 1) the more-intensive sampling, 2) lightning fires that may have spread easily into the drainage from the Big Prairie grasslands, and 3) occasional Indian-caused fires that also may have spread in from campsites on Big Prairie. There has not been a spreading fire in the drainage in the 56 years since 1926.

The first evidence of largely drainage-wide stand-replacing fires was during the 28 year period from 1655-1683 (fig. 14). The evidence is fragmentary, but 1-3 fires in excess of 6000 acres (2429 ha.) occurred during this time. These were followed by 11 or 12 smaller fires, in various locations, in the 169 years until the next large stand-replacing fires of 1852 and 1866. Most of these smaller fires were underburns, judging from the age class data, and only one may have exceeded 1000 acres (405 ha.). The 1852 and 1866 fires resulted in extensive lodgepole pine age classes. Six fires occurred in the drainage over the next 60 years until 1926, but again only 1 or 2 may have exceeded 1000 acres (405 ha.). Most of the smaller fires after 1866 did not

Figure 14. Akakola Creek fire history (fires of less than 50 acres not shown).

r = largely stand-replacing fire.



initiate seral regeneration.

The overall fire pattern was one of 1 or 2 underburns in lodgepole pine stands before an eventual stand-replacing fire after 100-150 years, while the resistant old growth larch and ponderosa pine have so far been underburned as many as 4-6 times. By 1982, or 116 years after the last major stand-replacing fire, virtually all of the lodgepole pine stands had been killed by mountain pine beetles.

Bowman Creek. This sample area is about 6000 acres (2429 ha.)(fig. 13), with elevations ranging from 3560-5200 feet (1085-1585 m.). About 60% of the sample area is along the lower slopes, with the remaining 40% in mid- to upper-slope stands.

Between 1667-1926, fires occurred at average intervals of about 18 years. As is the case with Akakola Creek, there has not been a spreading fire in this drainage since 1926. The first evidence of a largely drainage-wide stand-replacing fire was in 1667, apparently 6000+ acres (2429 ha.)(fig. 15). Another fire in 1683 burned as much as 50% of the area, resulting in comparable acres of underburn and regeneration of larch and, presumably, lodgepole pine. This was followed by at least 7 smaller fires, in various locations, 2-4 of which were small underburns of less than 1000 acres (405 ha.) each. The next major stand-replacing fire occurred 169 years later in 1852, resulting in an extensive lodgepole age class. This was followed by 6 smaller fires in various locations, but 3 or 4 were extensive underburns perhaps exceeding 1000 acres (405 ha.) each.

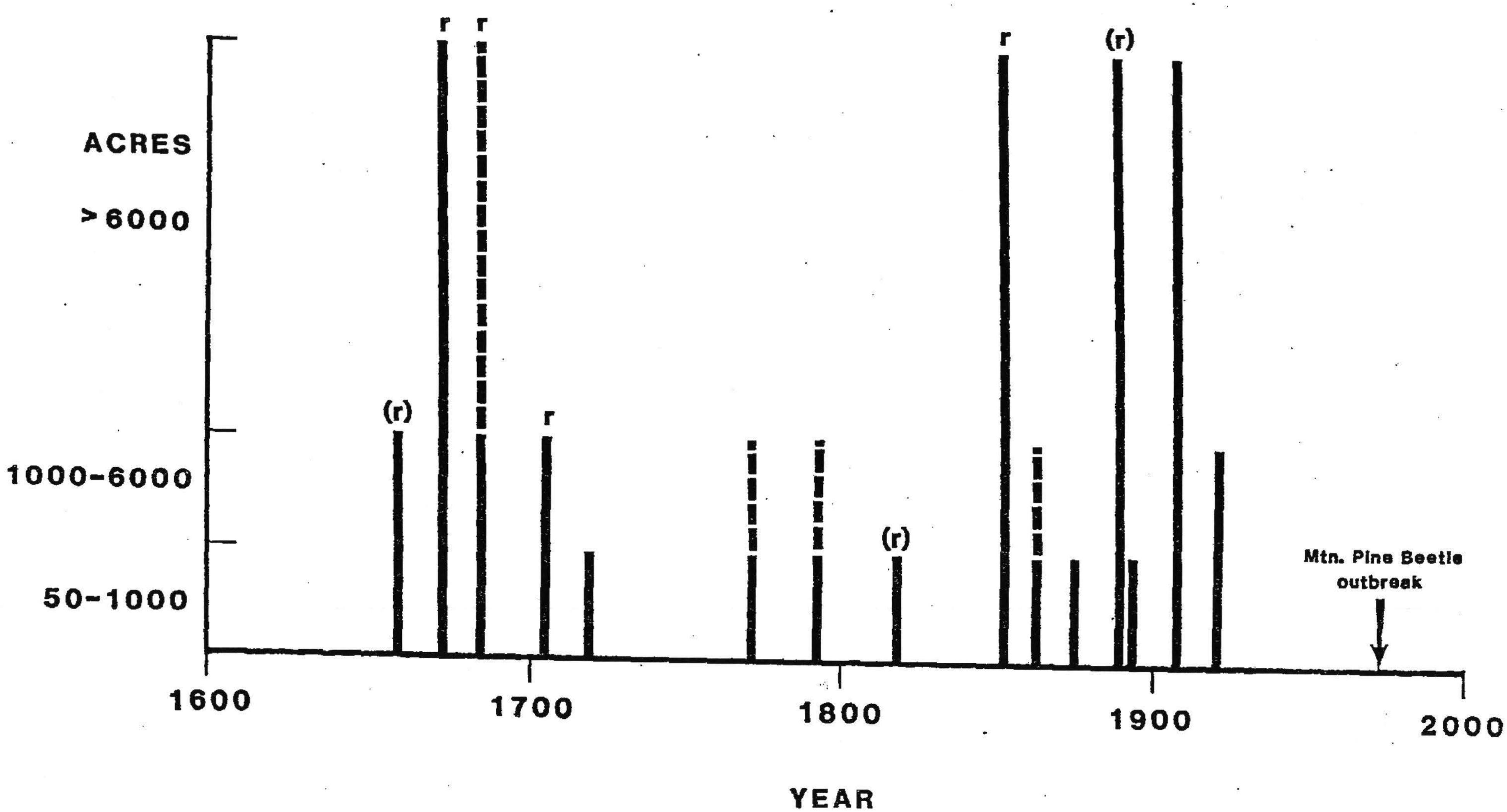
The overall fire pattern was one of 1 or 2 underburns in

-1910 & '26 in bowman

lodgepole pine stands before an eventual stand-replacing fire, usually after 100 years. By 1982, or 130 years after the last extensive stand-replacing fire, virtually all of the lodgepole pine stands had been killed by mountain pine beetles.

Figure 15. Bowman Creek fire history (fires of less than 50 acres not shown).

r = largely stand-replacing fire.



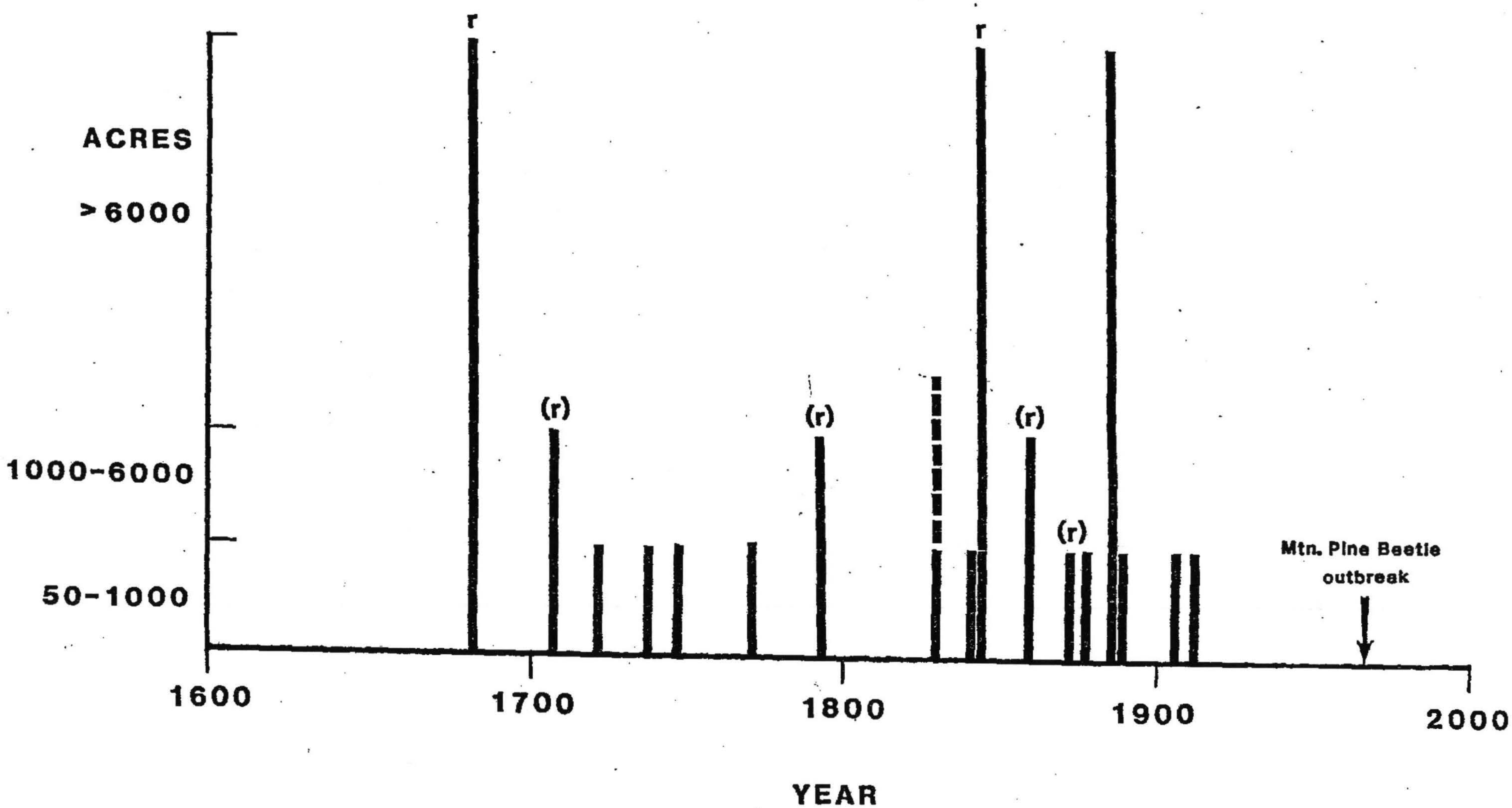
Quartz Creek. This sample area is about 6000 acres (2429 ha.)(fig. 13), with elevations ranging from 3520-5120 feet (1073-1561 m.). About 75% of the sample area is along the lower slopes, with the remaining 25% in mid- to upper-slope stands.

Between 1683-1910, fires occurred at average intervals of about 14 years. There has not been a spreading fire in the drainage since 1910. The first evidence of an apparently drainage-wide stand-replacing fire was in 1683 (fig. 16). This was followed by at least 8 smaller fires, 5 or 6 of which were mostly underburns less than 1000 acres (405 ha.) each. The next major stand-replacing fire occurred 161 years later in 1844, resulting in an extensive lodgepole pine age class. This large 1844 fire was followed by at least 7 smaller ones, 5 of which again were mostly underburns of less than 1000 acres (405 ha.) each, although an extensive underburn occurred in 1887.

The overall fire pattern was one of 1 or 2 underburns in almost any given lodgepole pine stand before stand replacement after 150 years. By 1982, or 138 years after the last major stand-replacing fire, virtually all of the lodgepole pine stands had been killed by mountain pine beetles.

Figure 16. Quartz Creek fire history (fires of less than 50 acres not shown).

r = largely stand-replacing fire.



Logging Creek. This sample area is about 4000 acres (1619 ha.)(fig. 13), with elevations ranging from only 3440-3840 feet (1049-1171 m.). The entire sample area is along the lower slopes.

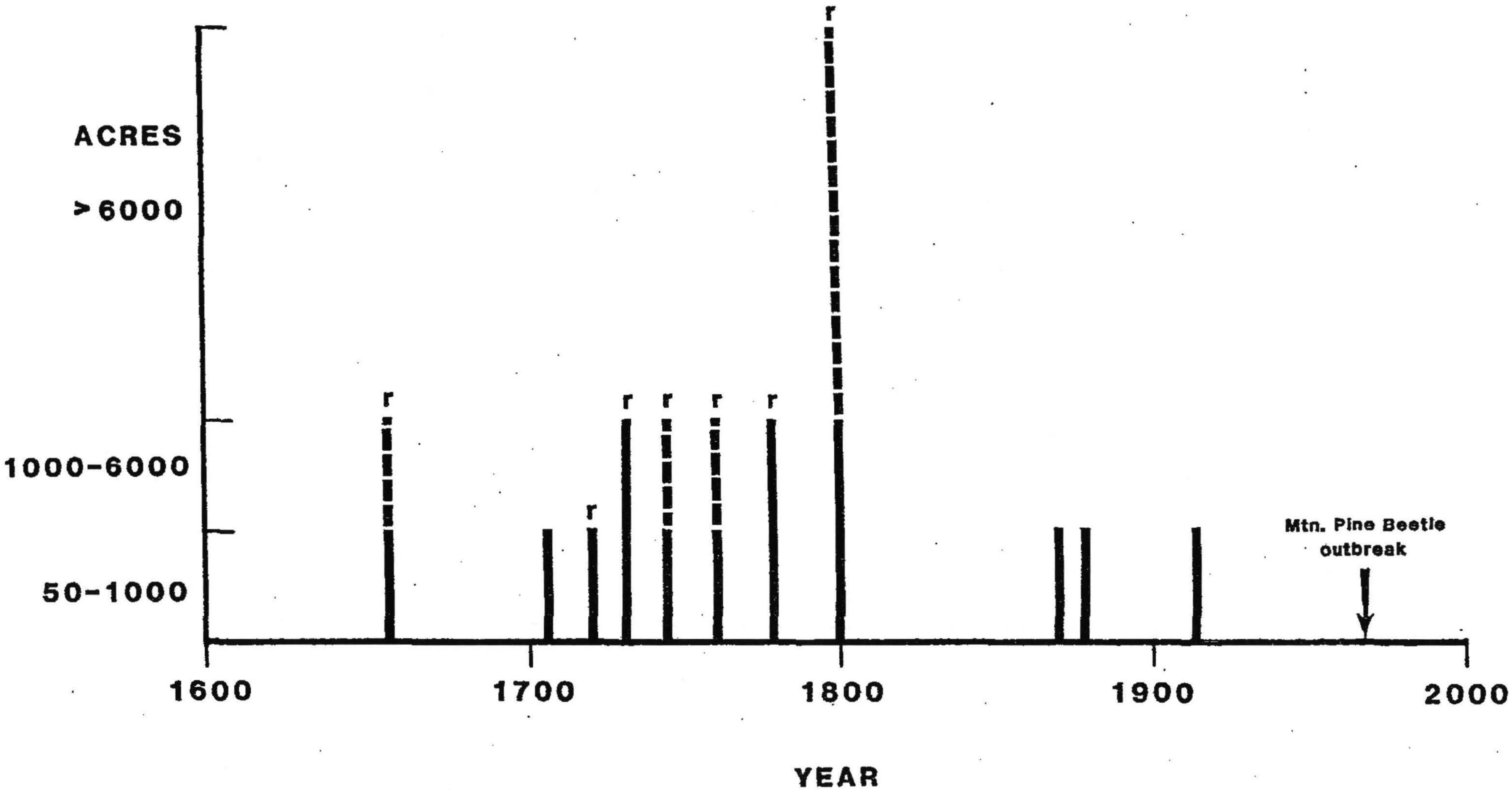
Between 1655-1914, fires occurred at average intervals of about 26 years. This relatively long MFI may have resulted because the sample area is relatively small, with the samples topographically restricted to the lower slopes. There has not been a spreading fire in the drainage since 1914.

The first fire evidence was in 1655 (fig. 17); 7 relatively small, mostly underburns occurred from this time up until a moderately large, stand-replacing fire in 1800. Only 3 small fires have occurred in the sample area since 1800, indicating an overall lack of fire activity over the past 182 years. This might simply reflect the lower topography of the sample area, rather than any inherent difference in fire history compared to other drainages.

The overall fire pattern was one of 1 or 2 underburns in almost any given lodgepole pine stand. By 1982, or 182 years after the last stand-replacing fire, virtually all of the drainage's lodgepole pine stands had been killed by mountain pine beetles.

Figure 17. Logging Creek fire history (fires of less than 50 acres not shown).

r = largely stand-replacing fire.



In summary, there has been a strikingly similar fire pattern among the 4 drainages. There seemed to be a repeating cycle of multiple underburns, some quite extensive, followed by a large stand-replacing fire usually after 100-180 years. Past mountain pine beetle epidemics might well be reflected in this pattern. As supporting evidence, most North Fork lodgepole stands have experienced underburns in the past 100-150 years, followed by beetle mortality beginning in 1972. The expected fuel buildups in the coming decades (Armour 1982) presumably will again set the stage for major stand-replacing fires.

Stand Fire History

Fire history also was examined in 20 small stands of less than 100 acres (40 ha.) each, usually along the lower-elevation benchlands (fig. 18). These stand locations reflect the inherently longer fire record available in the lower elevations, due to the less frequent occurrence of stand-replacing fires. Stand fire history was partitioned to reflect 3 cultural periods, first defined by Singer (1975): (1) the Presettlement Period (pre-1900), (2) the Settlement Period (1901-1930), and (3) the period of Efficient Fire Suppression (1931-1982).

Methods of calculating stand fire frequencies were as follows. To be considered a fire, an adjusted fire scar date generally had to be verified by at least 2 sample trees in the stand; an unduplicated fire scar occasionally was considered to be a fire, however, when the scar occurred within a clear sequence of fire scars on a tree, and gave indications of being a fire scar (showing such diagnostic attributes as a marked slowdown or increase in ring growth immediately after the scar, or charcoal presence within the scar formation). Also, unduplicated scars were considered to be reliable indicators of fires only when the scars were obtained from multiple-scarred old growth larch and ponderosa pine (such scars probably were from tiny spot fires in the stand). Lodgepole pine was not considered to be a reliable source of unduplicated fire scars because this species is often scarred by other sources. After thus determining the number of fires in a given stand, mean fire intervals (MFIs) were calculated. This was done by dividing the

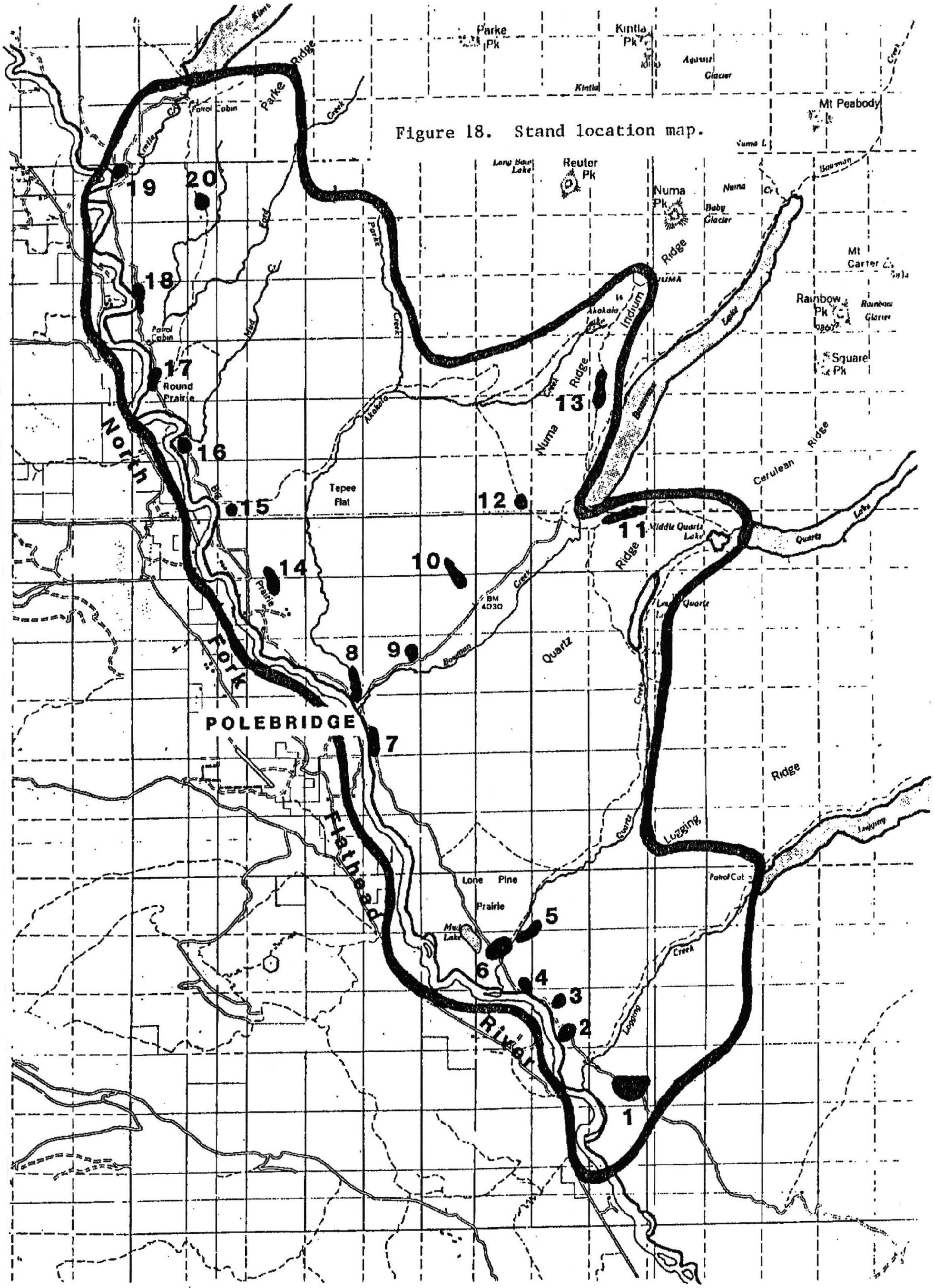


Figure 18. Stand location map.

number offire intervals into the total years of the fire chronologies within the 3 historical periods (pre-1900, 1901-1930, 1931-1982).

The objective of examining stand fire history was to give managers an idea of fire occurrence in small land units, for example, as an ecologically-based guide to scheduling prescribed burns. Also, stand MFIs provide a basis for interpretations about the effects of fire suppression in various habitat types. Stand fire frequency data likewise can aid interpretations about such topics as vegetation history and wildlife habitat.

Presettlement Period. Before 1900, stand MFIs ranged from 17-78 years, with the calculations beginning after 1655 (table 1). The fact that the study area is limited to such low elevations generally precludes being able to detect major frequency differences between stands, as might be expected in a more diverse study area. The possible exceptions are in stands 10, 11, and 12. These higher ridgetop stands' MFIs ranged from 74-78 years, suggesting the longer mean intervals that might be expected in the upper elevations. Most of the lower-elevation stands, however, had MFIs ranging between 25 and 55 years, agreeing fairly well with Singer's (1975) estimates.

I also examined the actual intervals between consecutive fires (table 1). Such information can be used, for example, as a natural guide for scheduling consecutive prescribed burns on a site. Before 1900, fires usually recurred at intervals of between 15-80 years. However, some stands had fire intervals of as short as 5 years, and a few stands had very long intervals

(longest: 169 years).

Table 1: Fire occurrence for 20 stands during the Presettlement Period (pre-1900).

Stand No. *	Habitat Type **	Elevation ft.	Elevation m.	Master Fire Chronology (yrs.)	No. Fires	Actual Fire Intervals (yr. range)	MFI (yrs.)
1	Picea/Vaca & Clun	3500	1085	1655-1858	9	13-58	25
2	Picea/Clun	3480	1079	1694-1872	7	5-55	30
3	Abla/Vaca & Clun	3560	1104	1694-1832	4	32-68	46
4	Picea/Clun & Vaca	3520	1091	1760-1887	8	6-32	18
5	Abla/Vaca	3720	1153	1655-1871	11	12-33	22
6	Picea/Vaca	3520	1091	1683-1887	8	9-36	29
7	Psme/Vaca	3620	1122	1796-1866	3	22-48	35
8	Psme & Picea/Vaca	3620	1122	1667-1889	8	15-62	32
9	Picea/Vaca	3900	1209	1705-1895	6	6-64	38
10	Picea & Abla/Vaca	4440	1376	1655-1889	4	37-147	78
11	Abla/Vaca & Xete	5000	1550	1655-1889	4	10-108	78
12	Abla/Clun & Vaca	4600	1426	1667-1889	4	16-169	74
13	Abla/Clun	4700	1457	1667-1889	5	16-113	56
14	Psme/Vaca & Caru	3680	1141	1655-1889	10	10-72	26
15	Psme/Vaca & Caru	3680	1141	1814-1887	3	35-38	37
16	Picea/Vaca	3720	1153	1755-1866	6	13-46	22
17	Abla/Vaca	3680	1141	1655-1863	7	7-129	35
18	Picea/Vaca	3800	1178	1774-1876	7	7-38	17
19	Picea/Vaca	4000	1240	1774-1869	3	17-78	48
20	Abla/Libo & Xete	4520	1401	1768-1869	3	28-73	51
		(Range)				(Mean range)	(Grand mean)
		3480-5000	1079-1550			17-68	40

* Figure 18 shows stand locations.
** Abbreviations follow Pfister et al. (1977).

The study area lacks habitat type diversity, therefore, differences in fire frequency and effects are perhaps best described by referring to forest cover types. In this study, it would not be as useful to use habitat types as a basis for comparison, because similar habitat types often are found within the different forest types. For example, the riparian forests of spruce and black cottonwood often key to spruce/clintonia (clintonia phase) habitat type (Pfister et al. 1977). These stands experienced infrequent stand-replacing fires perhaps on the order of every 200 years or more, judging from age-class data (few fire-scarred trees were found in this zone). Underburns rarely occurred in these forests because they generally are too moist and often are dominated by thin-barked, fire-susceptible trees. However, this habitat type also can be found in some of the adjacent Douglas-fir/larch/ponderosa pine forests (often Vaccinium caespitosum phase), yet these stands frequently underburned, as many as 6 times, and had mean intervals of as low as 20-40 years. These underburns ranged from low- to moderately high intensities, and major stand-replacing fires occurred in these stands at intervals of from 100-300+ years. Finally, the North Fork's extensive lodgepole pine forests also can key to the spruce/clintonia habitat type (V. caespitosum phase), but these usually experienced only 1 or 2 low intensity underburns before eventual replacement at 100-150 years.

It is difficult to estimate past fire frequency for the small grassland inclusions, but adjacent fire-scarred ponderosa pines suggest that these areas burned at average intervals of 20

years or less. These fires undoubtedly were of very light severity. Currently, the grasslands have not burned in 56 years, or longer.

The tiny groves of fire-dependent aspen, found in openings within the Douglas-fir/larch forests, experienced total stand replacement perhaps every 50-75 years. This is based upon age estimates for today's stands and the fire intervals on adjacent fire-scarred larch. Underburns were not characteristic since this species is very thin-barked and, consequently, fire-susceptible. The area's aspen stands are now about 50-100 years old, some appear decadent, and all of the stands lack regeneration.

Settlement Period. Between 1901-1930, about two-thirds of the study area burned in just 3 seasons, 1910, 1919, and 1926, although only patchy stand-replacement occurred. Most of the sample stands had 1 or 2 fires each during this time (table 2), but it was not considered meaningful to calculate MFIs since the time span is so short. The overall results, however, suggest that fires still were frequent, and this generally agrees with Singer (1975). Same

Table 2. Fire Occurrence for 20 stands during the Settlement Period (1901-1930).

Stand No.	No. Fires
1	2
2	1
3	0
4	1
5	0
6	1
7	1
8	1
9	1
10	1
11	0
12	1
13	0
14	1
15	2
16	2
17	3
18	2
19	1
20	1

Efficient Fire Suppression. The GNP fire atlas indicates that fires were largely precluded from the upper North Fork valley after 1926. This is well reflected by the sample trees in nearly every stand (table 3); 18 of 20 stands had no fires, and the remaining 2 stands had only 1 fire each.

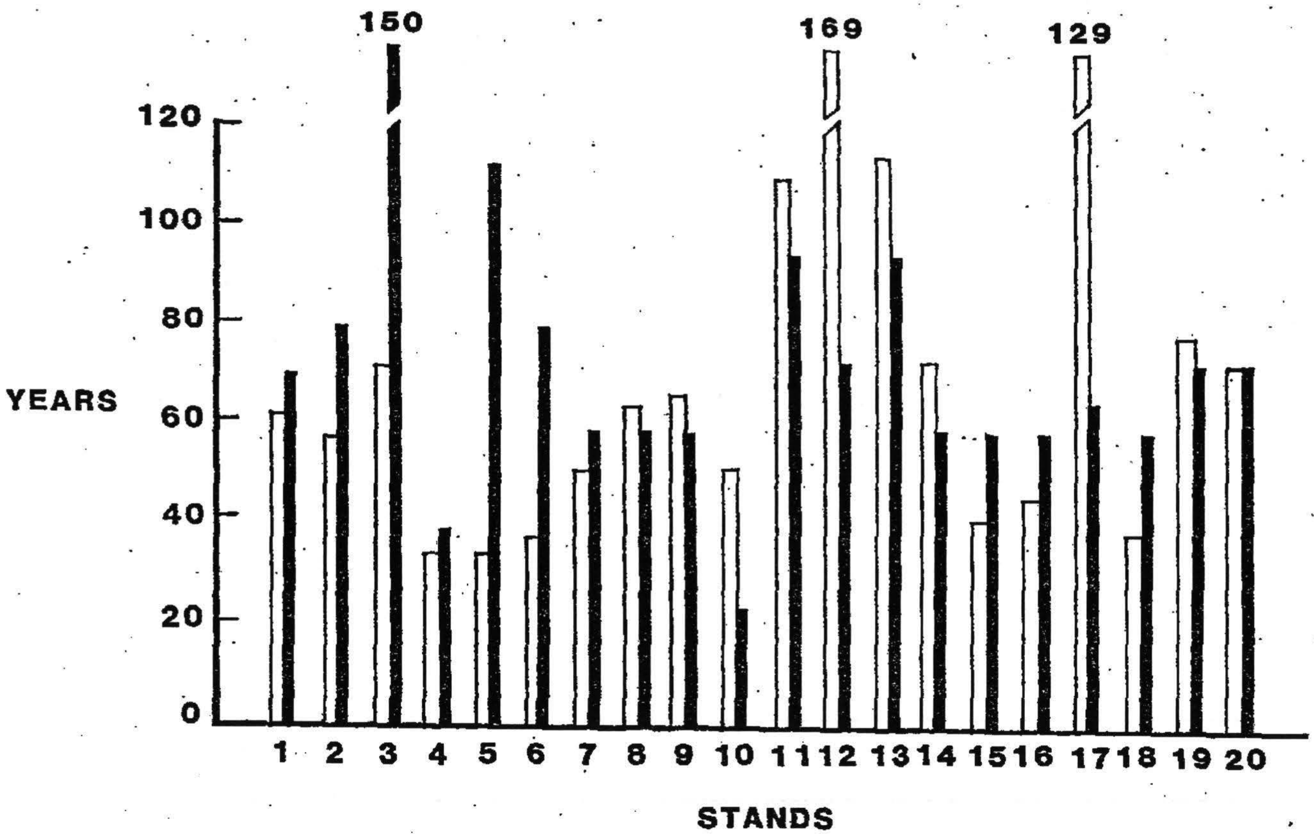
Same w/o citation

Before re-introducing fire into interrupted ecosystems, managers should know when the last fires occurred in a given area. This information can be useful, for example, in deciding which of 2 given stands might require the more immediate fire treatment. The "years-since-last-fire" statistic is used here, and I examined this figure for all 20 stands (table 3) as well as for the 4 large drainages. Currently, most stands in the study area have not experienced fire in the last 56-95 years; the fires of 1887, 1889, 1910, and 1926 collectively burned about 90% of the study area, and probably a much larger portion of the upper North Fork valley, judging from the written records (Ayres 1900, GNP Fire Atlas). This means that most North Fork forests are approaching or have just exceeded the upper limits of their past range of fire intervals (fig. 19).

Table 3. Fire Occurrence for 20 stands during the Period of Efficient Fire Suppression (1931-1982).

Stand	No. Fires	Yrs. since Last fire
1	0	68
2	0	77
3	0	150
4	1	36
5	0	111
6	0	77
7	0	56
8	0	56
9	0	56
10	1	22
11	0	93
12	0	72
13	0	93
14	0	56
15	0	56
16	0	56
17	0	63
18	0	56
19	0	72
20	0	72

Figure 19. Stand fire intervals before and after efficient fire suppression.



▯ : Maximum fire intervals from 1655-1926.

▮ : Period of Efficient Fire Suppression; years since last fire.

Fuel Photo Appraisals

Fischer's (1981 a & b) photo guides were used for an appraisal of representative downed woody fuels throughout the study area. The overall goal of this approach was to supplement the fire history data with a general appraisal of current downed fuel conditions, to further develop the basis for interpretation about the effects of fire suppression.

The method was to, first, photograph representative fuels in stands along the 20 transects (fig. 20). The next step, in the office, was to compare the downed fuels in my photographs to similar ones published in Fischer's fuel photograph series. Fischer photographed a wide range of downed fuel conditions that often are found in Montana's forests. His series includes the forest cover types of the North Fork study area (the types are "Ponderosa pine-larch-Douglas fir", "Lodgepole pine", and "Englemann spruce-subalpine fir"). After obtaining numerous photographs of representative fuel conditions, he then analyzed a number of fuel parameters, such as number of tons per acre of various fuel diameter classes. These analyses led to an estimate of overall fire potential for each photographed stand (this is a subjective index based upon potential intensity, rate of spread, and resistance to control [cf. Fischer 1981c]). Note, however, that the appraisals are based solely upon downed woody fuels; the method does not account for living "ladder" fuels nor, in this study, can it account for the many tons per acre of standing 1000-hour time lag fuels, created by the recent mountain pine beetle epidemic. Still, Fischer's guide for appraising downed

fuels is useful for obtaining a general description of this important component of the fuel complex.

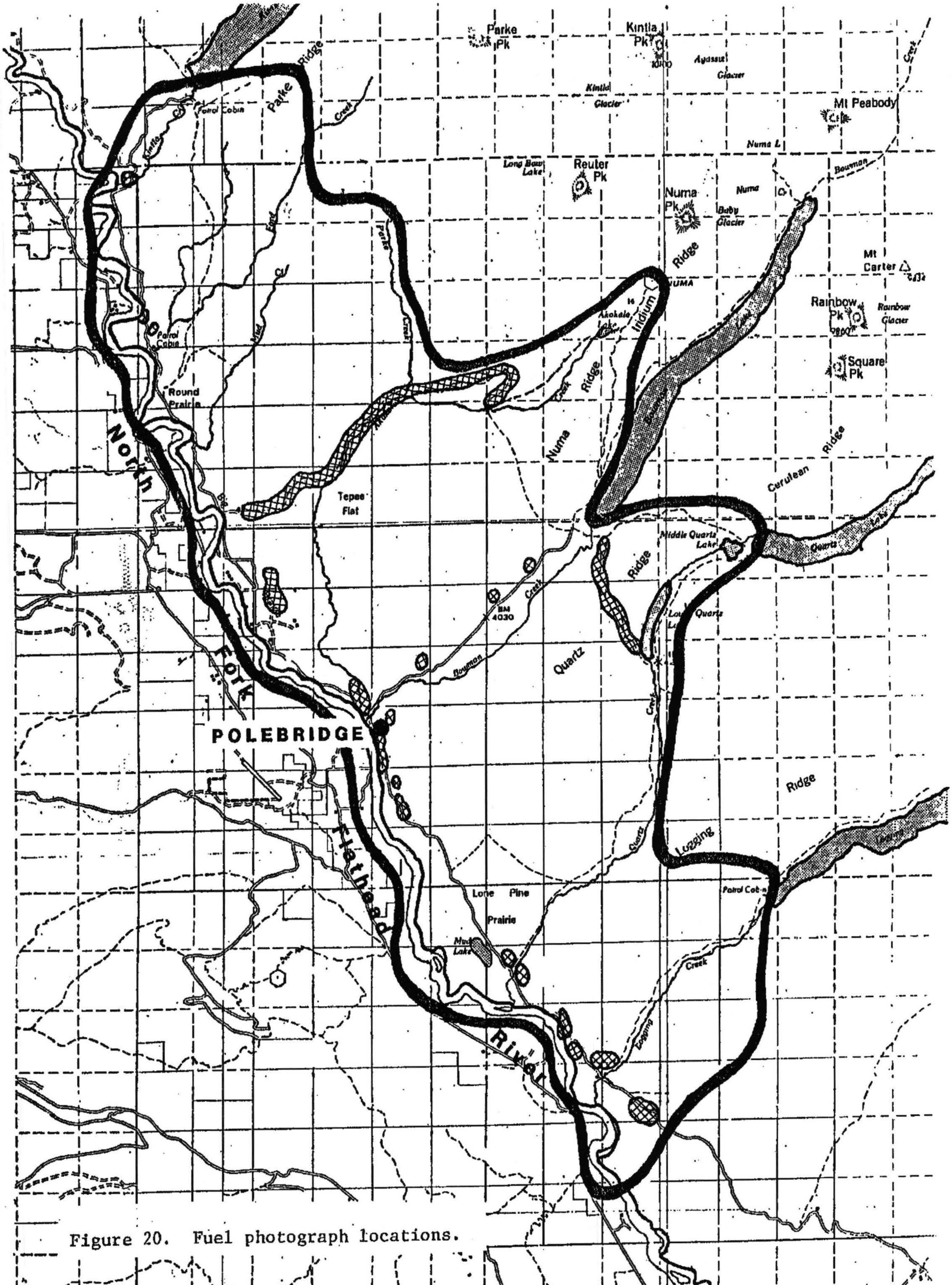


Figure 20. Fuel photograph locations.

Evaluation of 149 photographs suggests that most stands have a low- to medium overall fire potential. No high or extreme fire hazard situations were identified in this study. The fire history data, and field observations, concur with these findings. Many stands have either originated or have experienced surface fires within the last 50-100 years, thus the fuel appraisal results generally reflect this fairly recent and widespread fire activity.

Specifically, 54% of the 149 stands photographed were in the medium overall fire potential, while the remaining 46% are in the low potential category. In terms of potential hazard by forest cover type, most downed woody fuels in the generally open lodgepole pine stands are well-spaced 100+-hour fuels, usually with a paucity of fine fuels. There also is a general lack of live fuels between ground and crown, in most cases. Conversely, in the more-heavily forested ponderosa pine-larch-Douglas fir stands, overall tons per acre increase, fuels generally become more closely spaced, and there is a wider distribution of fuel diameters. Live fuels, in the form of understory Douglas-fir and spruce, also are often considerable in these stands. Presently, these stands seem to have a greater potential for moderately intense fires.

The GNP fire atlas also contains subjective fuel hazard ratings for forests in the former "Bowman Lake" Ranger District (current study area). These appraisals were made after intensive field surveys between about 1930-1950. During that time nearly 75% of the area was assigned to the low- or medium hazard class,

with about 50% in the low rating.

Lunan (1972) examined 5 ponderosa pine stands and found relatively large loadings and horizontal distributions of litter and duff, compared to other fuels. Lunan's "Stand 1" is the currently planned "Ponderosa Burn" (Wakimoto 1983); Wakimoto concurred that most surface fuels in this stand were litter, duff, and decayed 1000-hour fuels. In terms of live fuels, he found that Douglas-fir and spruce saplings formed significant aerial fuels in parts of the stand. This understory development partially reflects the effects of fire suppression, because surface fires frequently occurred in this stand before 1930 and these probably would have kept the stand more open than at present (this stand also is my "Stand 1" and it had a pre-1930 MFI of 26 years). Examination of lightning fire distribution for the last 50 years (fig. 12) reveals that 6 class A fires have been suppressed in the immediate vicinity of this stand, perhaps suggesting that the stand's natural fire frequency has been interrupted. Currently, the 68 years since the last fire have just exceeded the historical maximum of 58 years between consecutive events (fig. 19).

In the lodgepole pine stands, Armour (1982) modeled fuel succession at various stages 2-80 years after mountain pine beetle mortality. His fuel models suggest that there now is a low hazard of stand-replacement fires in recently killed stands, because most of the canopies' very extensive dead needles have fallen to the forest floor. In the moist habitat types such as spruce/clintonia, the models suggested that the fuel buildups that may be required for the development of crown fires may not

occur for decades (specifically, after succession year 80 following beetle mortality). The recent pine beetle epidemic apparently has provided the catalyst for this expected future buildup; the developing climax tree canopy eventually will combine with the many tons per acre of fallen lodgepole pines, resulting in very heavy loadings of live fuels and large downed woody fuels.

Armour's study further suggested that continued fire suppression may eventually result in the drier habitat types developing a fuel succession similar to that of the moist types. This phenomenon might occur because of the increased development of ladder fuels in the understory, which were previously reduced by periodic underburns.

MANAGEMENT IMPLICATIONS

The ultimate goals of this study were to provide GNP managers with information about fire's past role in the North Fork's ecosystems. Accordingly, the data lead to the following management implications.

The overall picture of fire history in the North Fork is one of frequent and extensive underburns followed by occasional, severe stand-replacing fires. The valley's gentle morainal topography seems to contribute to this pattern of frequent underburns. This contrasts with the burning pattern of the steeper subalpine forests, which evidently are more prone to consecutive stand-replacing fires. In terms of planning for human safety, this difference in fire patterns is important since

most human activity and dwellings occur in the lower elevations.

The park's managers have wondered about the appropriateness and safety of applying prescribed underburns. The past occurrence of $\boxed{\text{extensive}}$ underburns in the North Fork drainage indicates that prescribed burning would simulate past fires. The currently low- or moderate-hazard fuels also suggest that prescribed burning should be feasible. Additionally, the stand-MFI data can serve as an ecologically-based guide to scheduling burns.

Questions have been raised about the current fire hazard in the aftermath of the mountain pine beetle epidemic. The study area has not experienced large stand-replacing fires in 100 years or more, and succession may now be progressing toward the occurrence of major fires. Armour (1982) suggests that this might be expected after the next several decades, and his models seem to fit well with the fire pattern found in the area's 4 drainages (these areas experienced major stand-replacing fires usually at 100-180 intervals). Presently, most North Fork stands still seem to have a low- to moderate fire hazard so Glacier seems to be in a good position to implement plans for lightning fires and planned ignitions.

The past occurence of extensive underburns in the study area translate into another important management implication; the 50 years of fire suppression probably have not yet produced major impacts on succession, in most stands. Much of the North Fork valley has burned within the last 56-95 years, meaning that many forests are just now on the upper end of the past range of fire intervals. Therefore, today's fuel loads probably do not differ

markedly from the extremes of the past. However, some forests immediately surrounding a few of the 20 sample stands already have considerably exceeded the upper limits of their past fire interval ranges (fig. 19); these primarily larch/Douglas-fir stands might now be the most logical areas to begin treatment with prescribed fire (fig. 18 shows the stands' locations). Other exceptions may be within the grassland prairies and in the scatterred small aspen stands. Koterba and Habeck (1971) documented a limited invasion of young lodgepole pines along the edges of Big Prairie and Round Prairie, as well as an increase in the distribution of big sagebrush. These changes were felt to be largely a result of fire suppression. Today's lack of aspen reproduction undoubtedly also can be attributed to fire's absence. These stands also are just now on the upper threshold ? Pg 45 of their fire cycle, having essentially the same frequency as the surrounding lodgepole/larch stands. Consequently, GNP still has the opportunity to re-introduce fire, through planned and unplanned ignitions, before substantial ecological impacts occur in the forest communities.

Unlike past studies (Habeck 1970, Lunan and Habeck 1973), my results do not support the contention that fire suppression has had a major impact on the area's limited old growth ponderosa pine stands (fig. 21). The earlier studies concluded that fire suppression was responsible for the overall lack of young ponderosa pines in the old growth stands (these stands also usually are co-dominated by larch and Douglas-fir). Currently the park's only well-stocked stand of young ponderosa pine

occupies a relatively dry, south-facing slope above lower Anaconda Creek, about 1 mile (

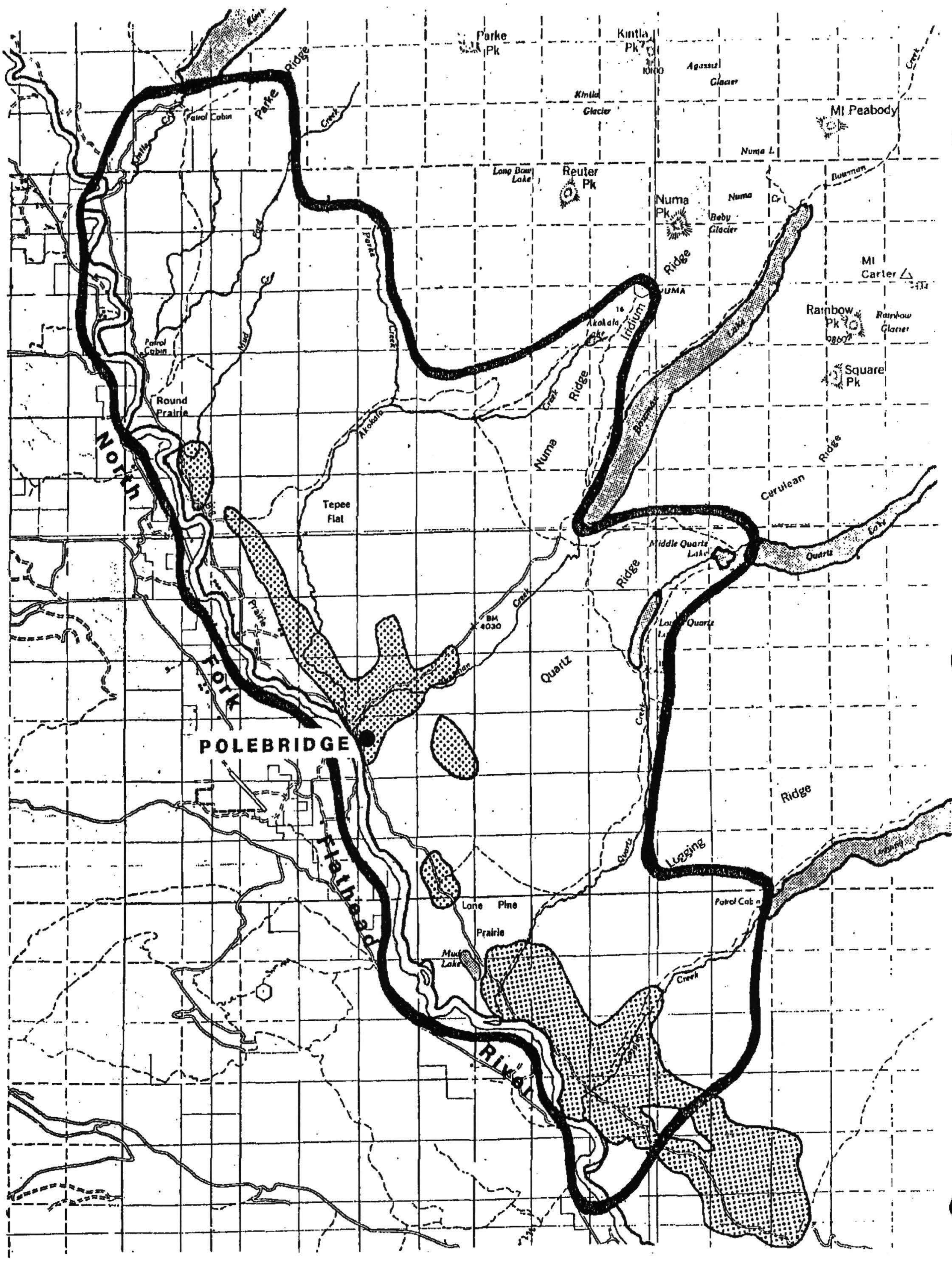


Figure 21. Extent of ponderosa pine in the upper North Fork valley.

(1.6 km.) southeast of the study area. This small stand regenerated after the 1910 fires. A few scatterred ponderosa pines also have successfully invaded the dry grassland/forest ecotone along Big Prairie. Otherwise, my age class data reveal that the area's last major pulse of ponderosa pine regeneration occurred over 2 centuries ago, after fires in 1735, 1745, 1760, and 1774. This species has thereby failed to regenerate despite the occurrence of frequent fires up until 1926. Since the park's ponderosa pine represent a cool-moist edge of the species' regional distribution, the overall regeneration failure of the past 2 centuries might reflect a fluctuating range. Therefore, the species' existence in the park may be tenuous, and fire occurrence may not be the most important factor controlling its regeneration.

These data thus suggest that some of today's prescribed-burn objectives, first proposed by the earlier research, might be ecologically inappropriate in the context of NPS national policy. The objectives call for preparation of mineral soil seedbeds specifically to promote ponderosa pine regeneration, giving it priority over that of other species. Similarly, the objectives set a maximum threshold of acceptible post-burn mortality for the old growth ponderosa pines, again without also targeting other species. In light of the unclear status of ponderosa pine, managers might consider deleting species-specific objectives, in place of applying fire in a manner consistent with past frequencies and intensities. Resultant vegetative responses presumably would be similar to those of the past, assuring

adherence to the national policy of perpetuating natural processes.

A final implication for prescribed burning comes from the fact that, historically, large fires swept across most of the North Fork valley without regard for today's agency boundaries. Five major fires burned both sides of the valley over the last 300 years, and some of these fires may have started outside the park. Thus the park's "buffer zone" idea of using prescribed fires for fuel reduction along the common boundary might be sound.

SUMMARY

In June 1982 Glacier National Park began a fire history study in the North Fork of the Flathead River drainage, to document fire's role before the onset of efficient fire suppression. The ultimate objective was to provide managers with the necessary information on past fire frequencies and severities in the area's lodgepole pine/larch and Douglas-fir/larch/ponderosa pine forests. These data were considered necessary in planning for lightning fires and prescribed fires, in the park's effort to perpetuate ecosystems in a manner similar to that which prevailed in pre-settlement times.

The 272 fire scar samples from the 60,000 acre (24,291 ha.) study area revealed 66 fire years from the 1470s-1960. The Master Fire Chronology, or the period of relatively continuous data, spanned 271 years, from 1655 until the onset of efficient fire suppression after 1926. Fifty-five fire years were identified for this period.

The overall picture of fire occurrence that emerged over 161 yrs. this 3-century span was one of frequent and sometimes extensive underburns followed by occasional, severe stand-replacing fires. Estimated mean fire intervals are as follows: large fires of 1000-10,000 acres (405-4049 ha.) occurred on the average of about 16-23 years within the 60,000 acre (24,291 ha.) study area; major fires in excess of 10,000 acres (4049 ha.) occurred on the average of about 39 years. There were 8 major fires, and an

increase in their frequency after the mid-1800s, and these often burned tens of thousands of acres or more. From about 1889 to 1926, however, some of these very large fires were still largely underburns in the study area. During the life of individual stands, lodgepole pine commonly survived 1-2 underburns before being killed in a stand-replacing fire, while many of the area's old growth larch, Douglas-fir, and ponderosa pine have been underburned as many as 6 times. Very few acres have burned in the upper North Fork valley since efficient fire suppression began in about 1930.

The study area, now in the final stages of a large mountain pine beetle epidemic, has not experienced a major stand-replacing fire in over a century. However, as much as 90% of the area has underburned within the past 56-95 years, and most stands are now approaching the maximum fire intervals that existed in pre-settlement times. Appraisals suggest that fuel buildups probably are not yet unusually large. Consequently, while the historic fire frequency has been interrupted, fire suppression evidently has not yet markedly influenced succession in most stands. Glacier National Park's current goal of implementing plans for prescribed fire and unplanned ignitions thus seem timely. Evidently the stage is now being set for major fires in the North Fork valley in the coming decades, with the recent mountain pine beetle epidemic providing the catalyst for expected fuel buildups.

In addition to providing baseline data, this study also resulted in a number of management implications which may aid

managers' compliance with the National Park Service policy of perpetuating natural ecosystems.

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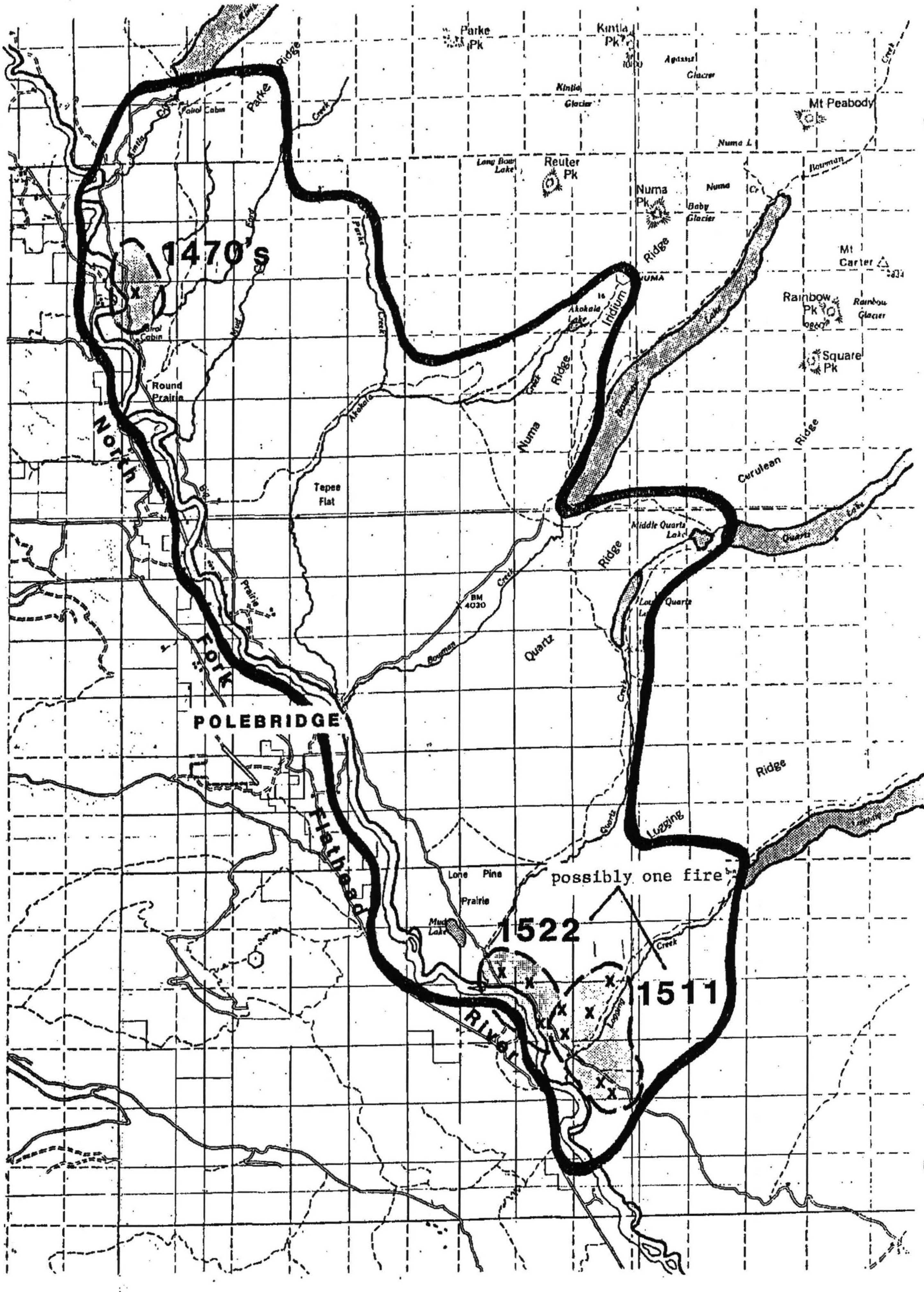
APPENDIX

Fire Maps. North Fork of the Flathead River Drainage
1470-1960



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Bowman
Mt Carter
Rainbow Pk
Rainbow Glacier
Square Pk
Parke Ridge
Kintla Cr
Patrol Cabin
Creek
1470's
Mud
Ford
Parke
Creek
Ridge
NUMA
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Ridge
Numa Creek
Bowman
Lake
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North Fork
Akokala
Tepee Flat
Numa
Curulean Ridge
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Quartz
Ridge
Lower Quartz Lake
Creek
BM 4020
Bowman
Quartz
Prairie
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Logging
Lone Pine Prairie
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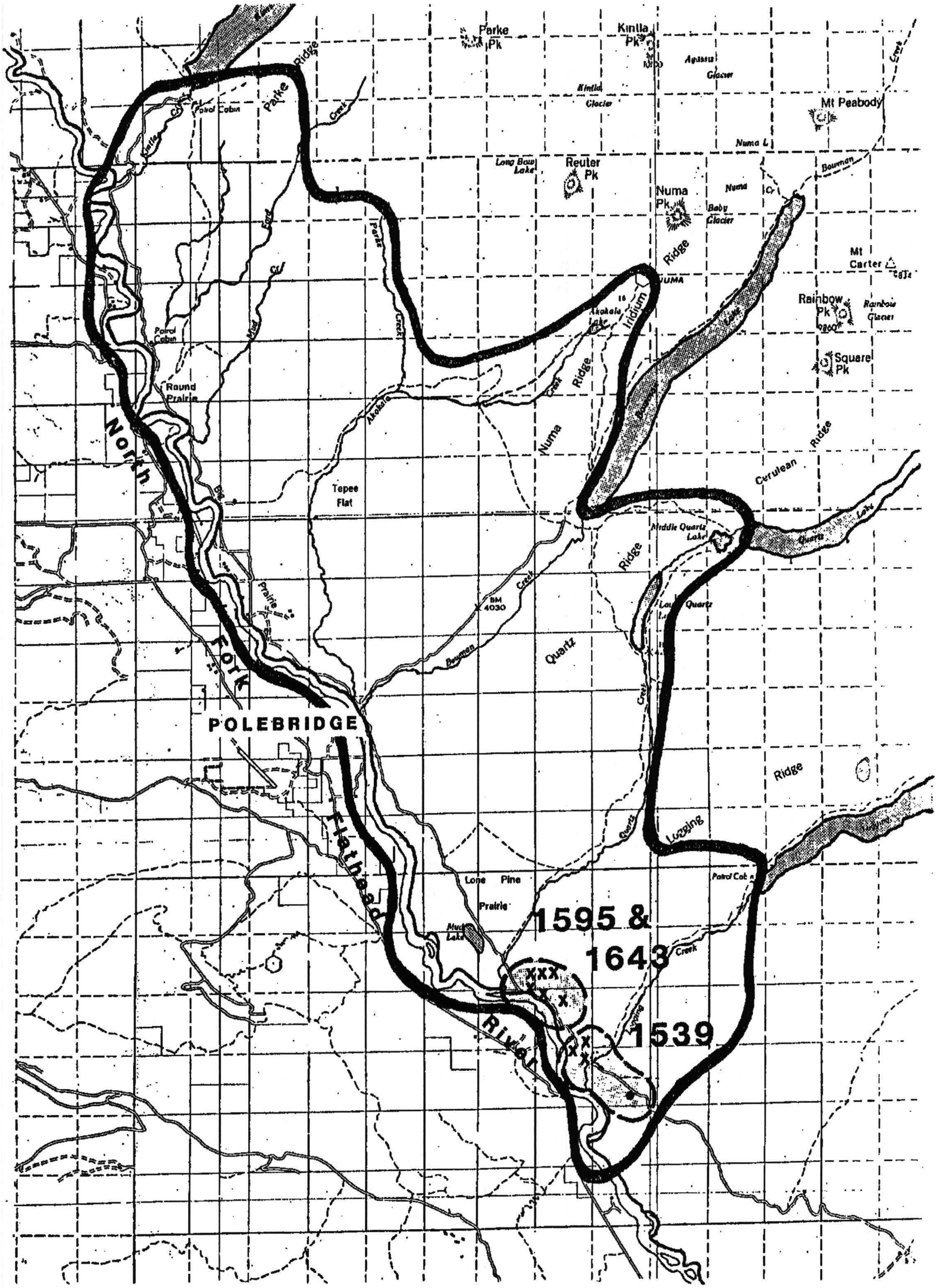
possibly one fire
1522
1511
Creek
Logging



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North
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1595 &
1643
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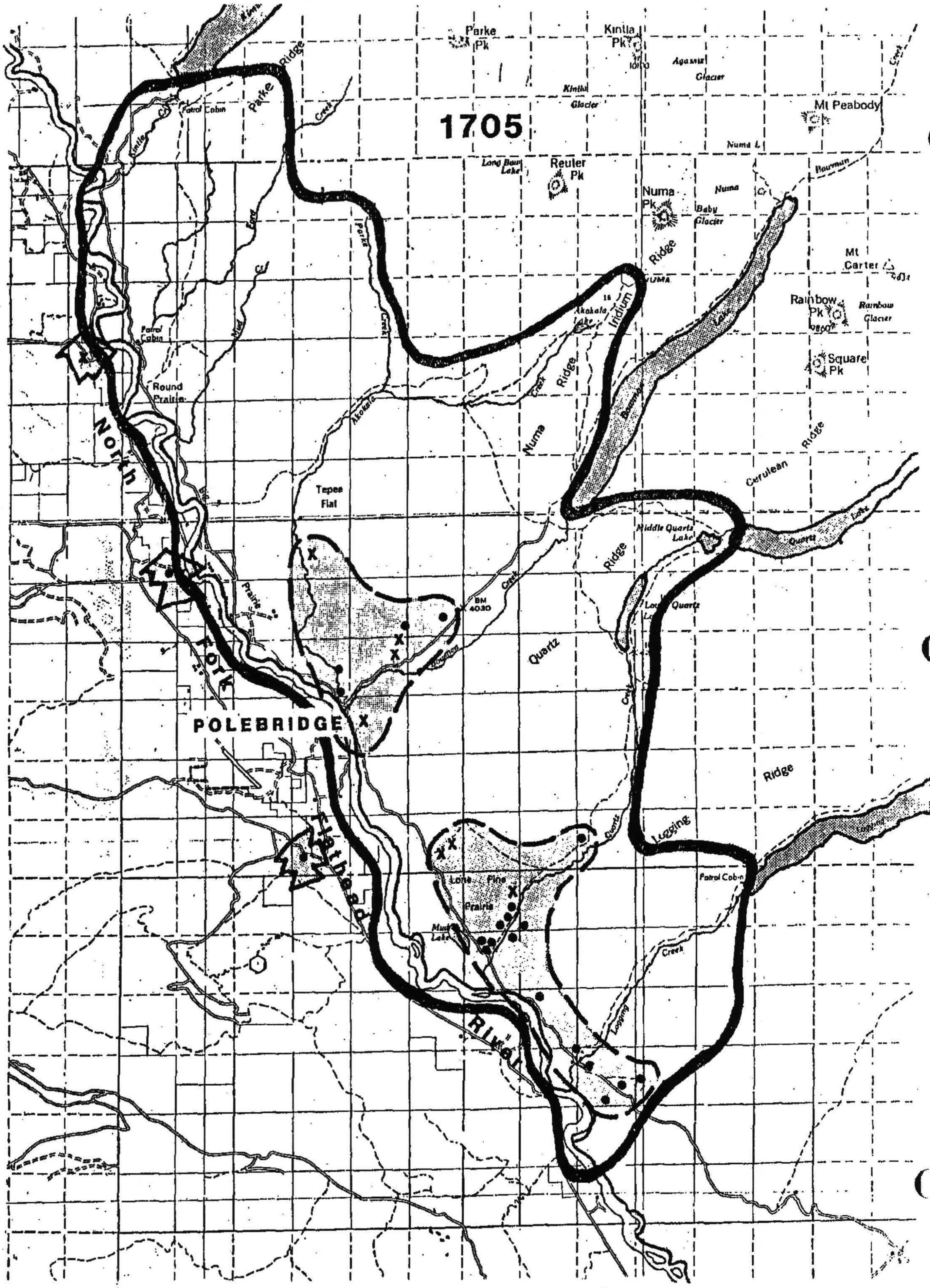

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Mt Carter
Rainbow Pk
Rainbow Glacier
Square Pk
Akokala Lake
Iridium Ridge
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Flathead River
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Bowman Lake
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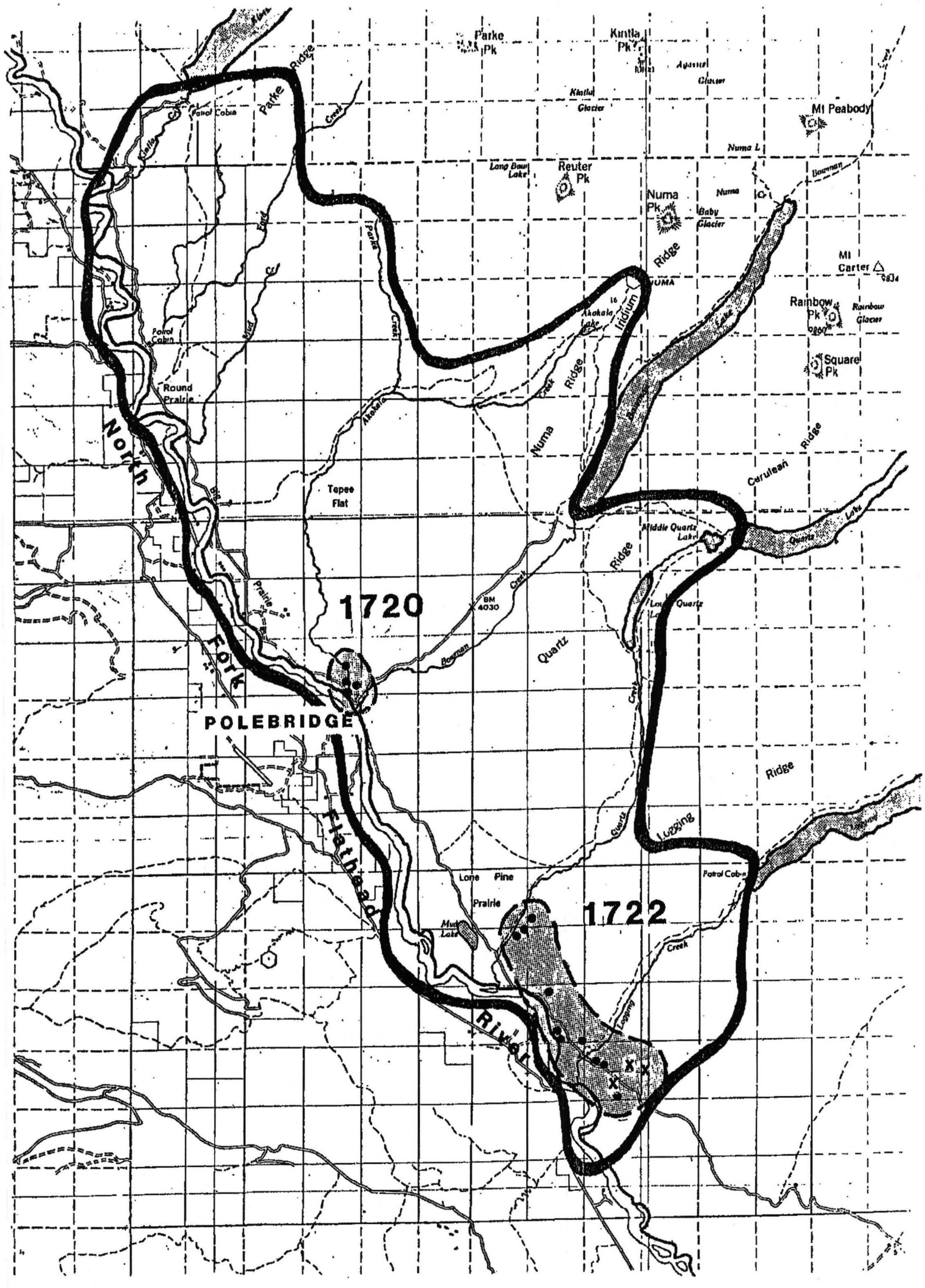
Logging Creek
Patrol Cabin



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Baby Glacier
Numa Cr
Ridge
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NUMA
Akokala Lake
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Rainbow Pk
Rainbow Glacier
Square Pk
Patrol Cabin
Round Prairie
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Prairie
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Logging
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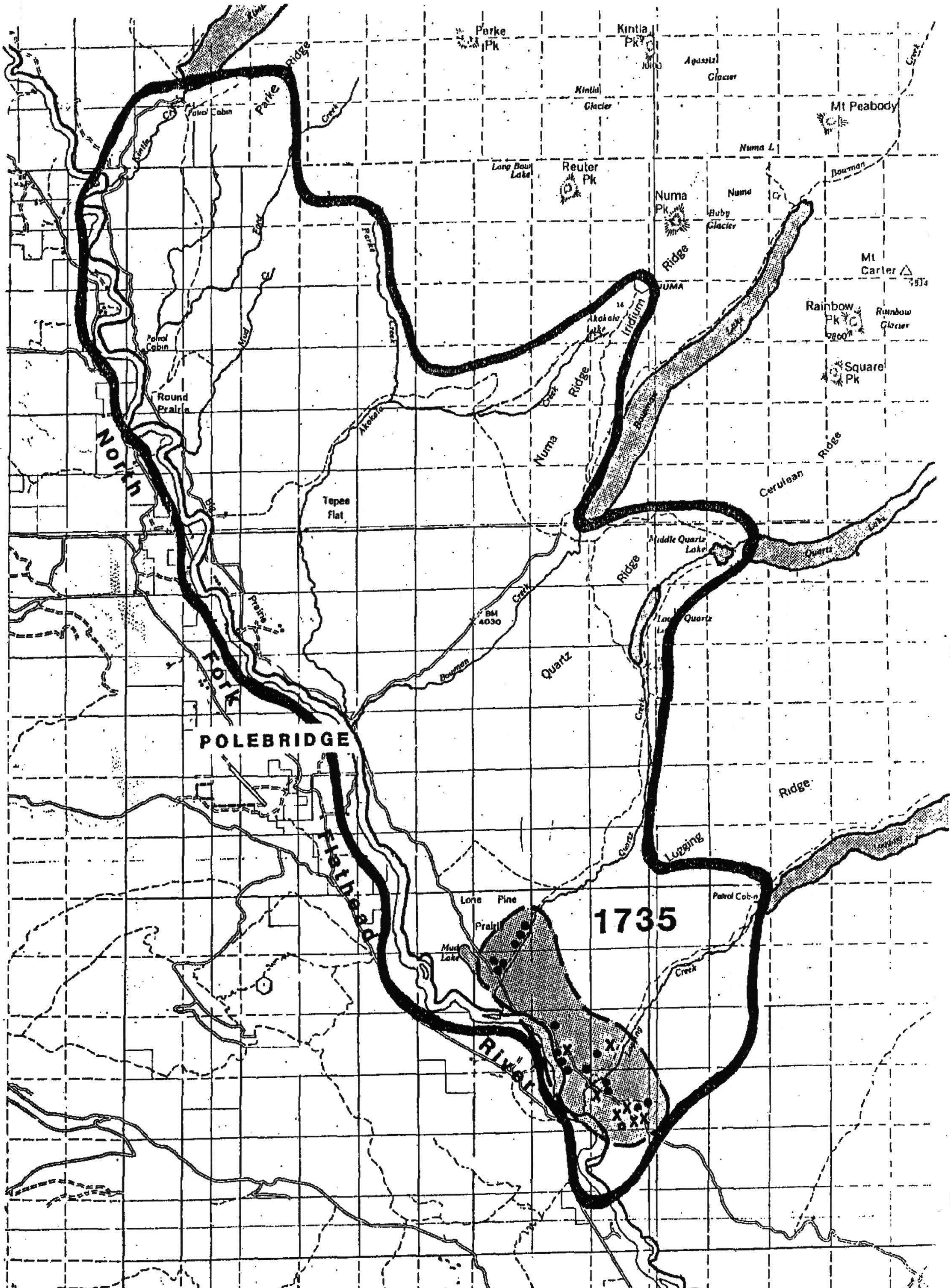
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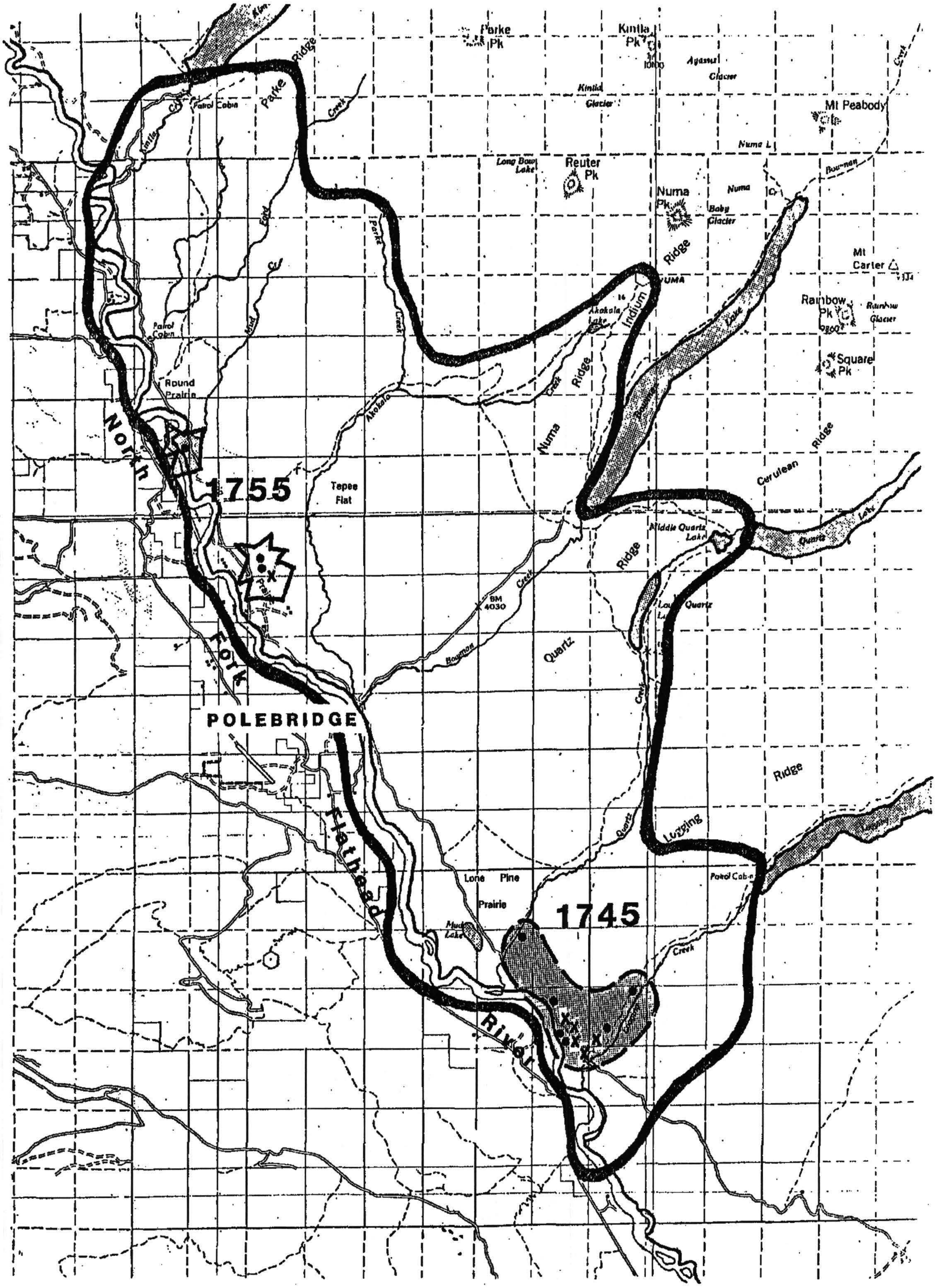

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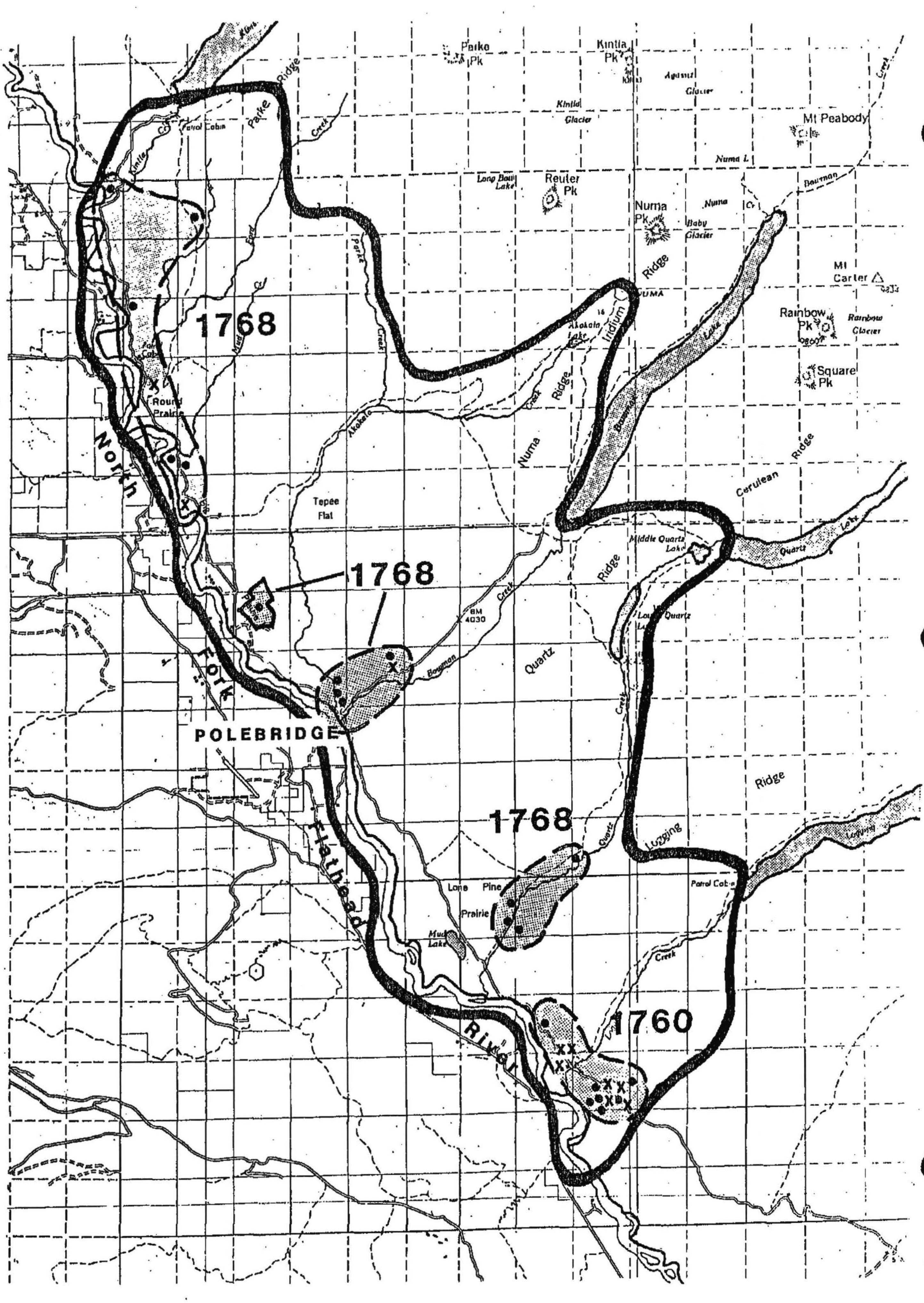

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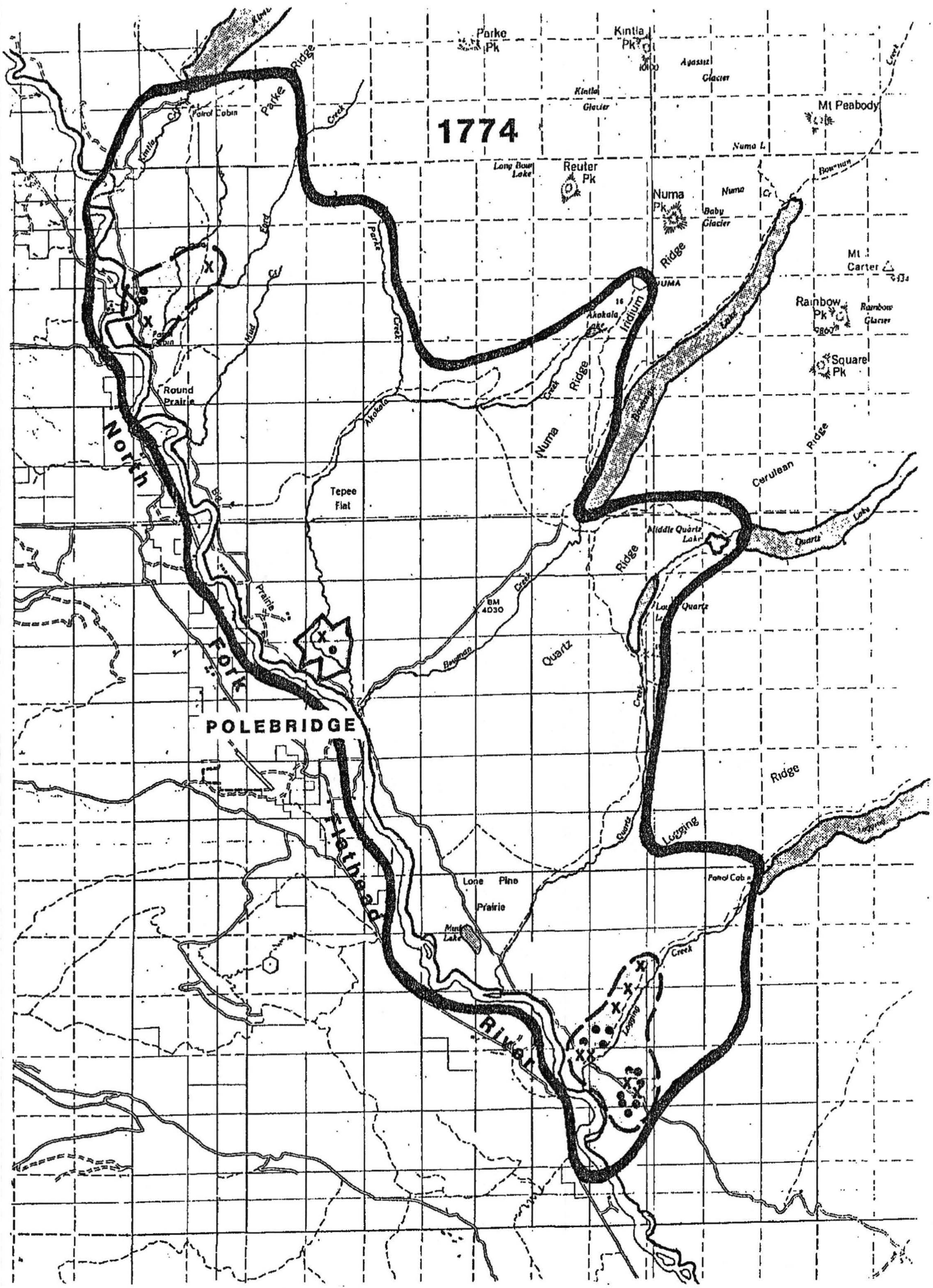

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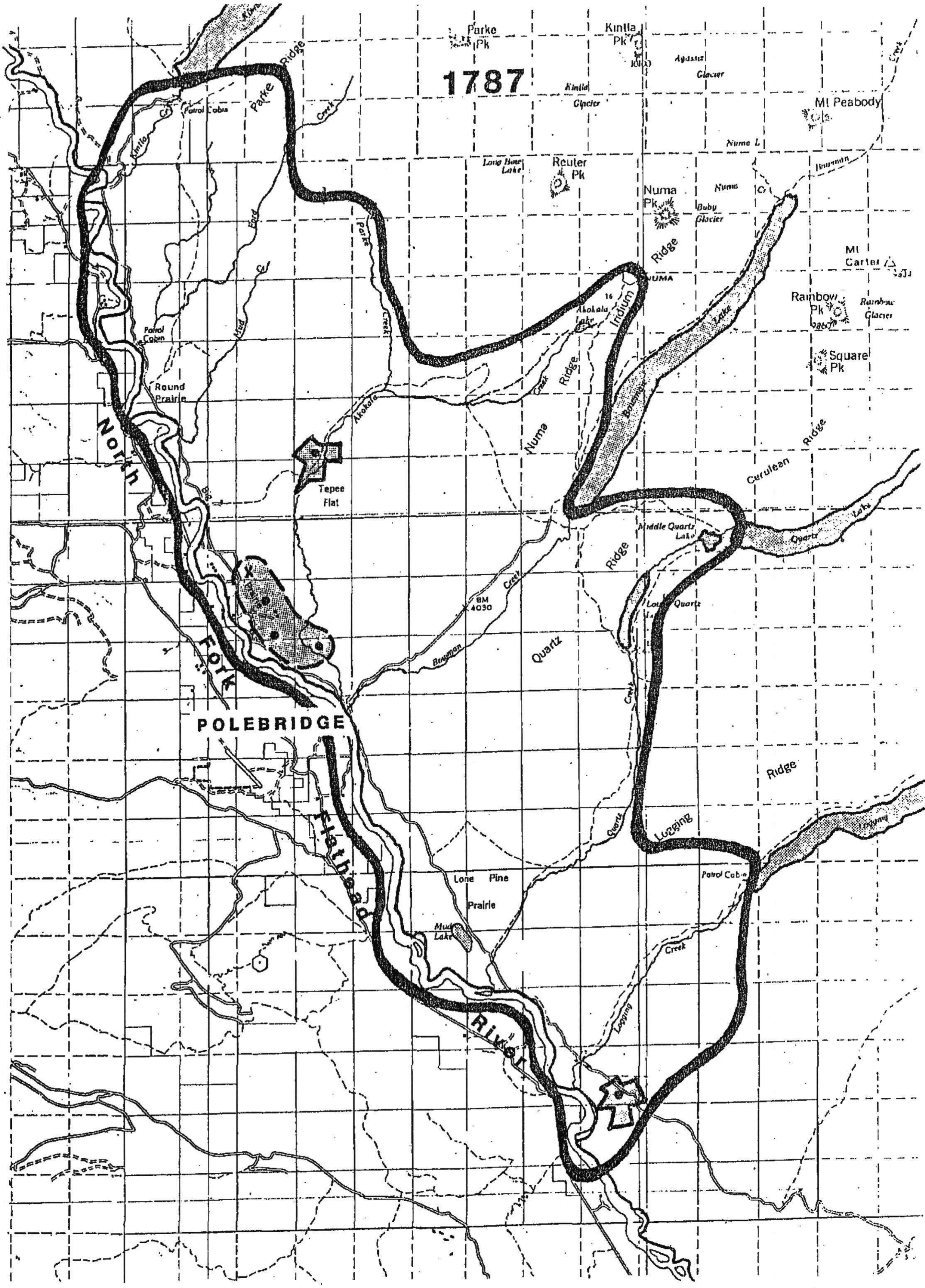

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Ford Cr
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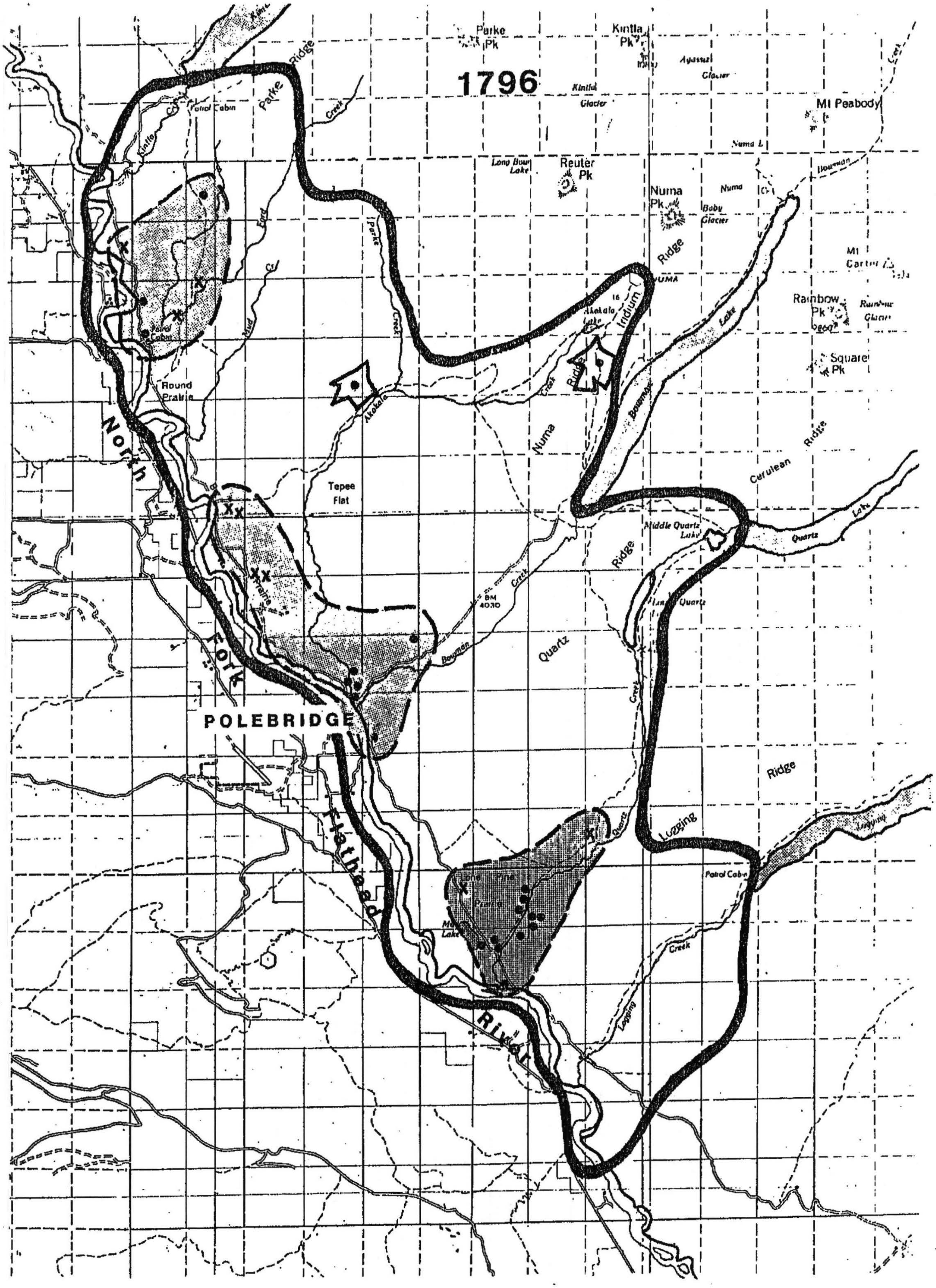

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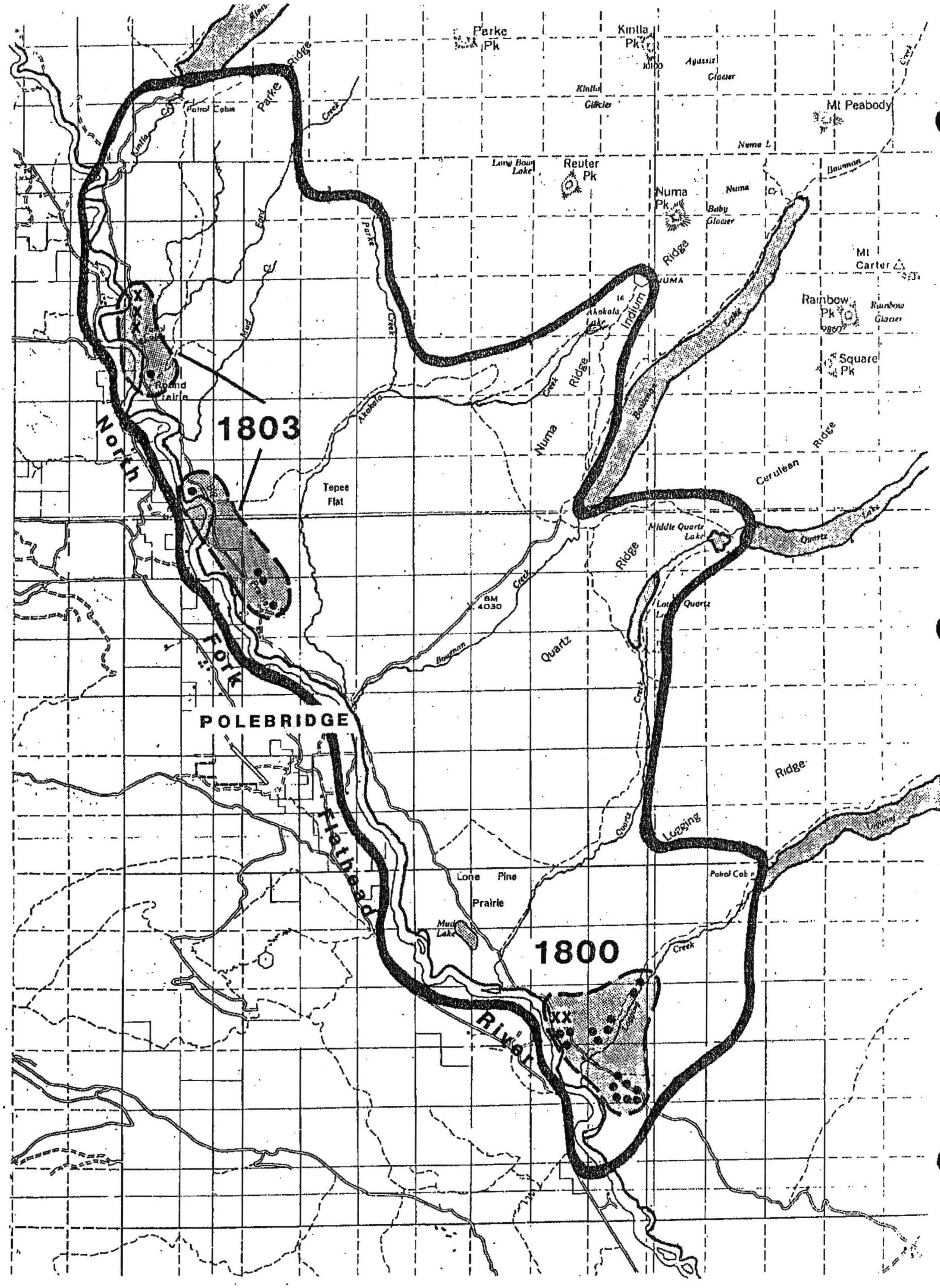
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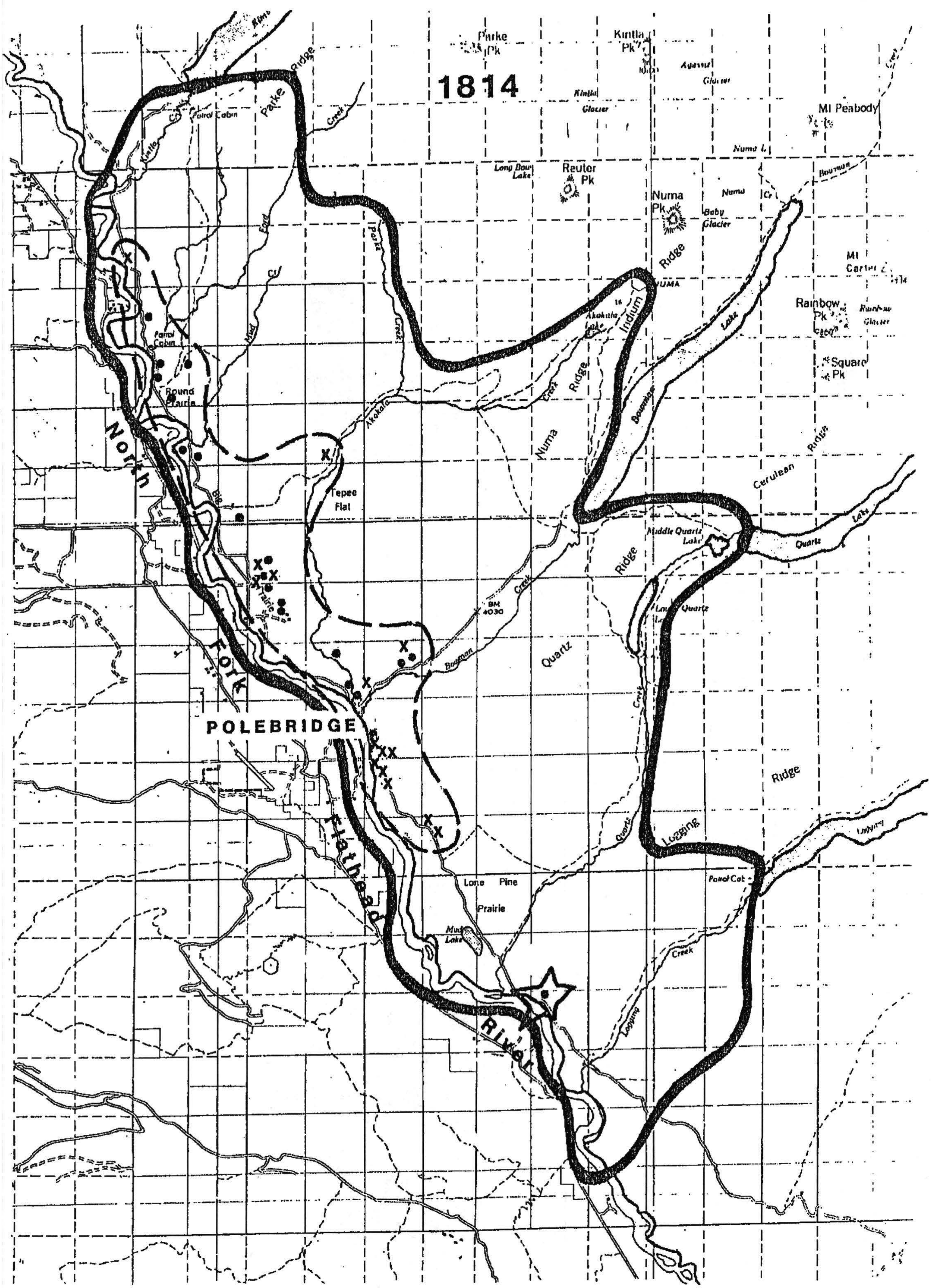

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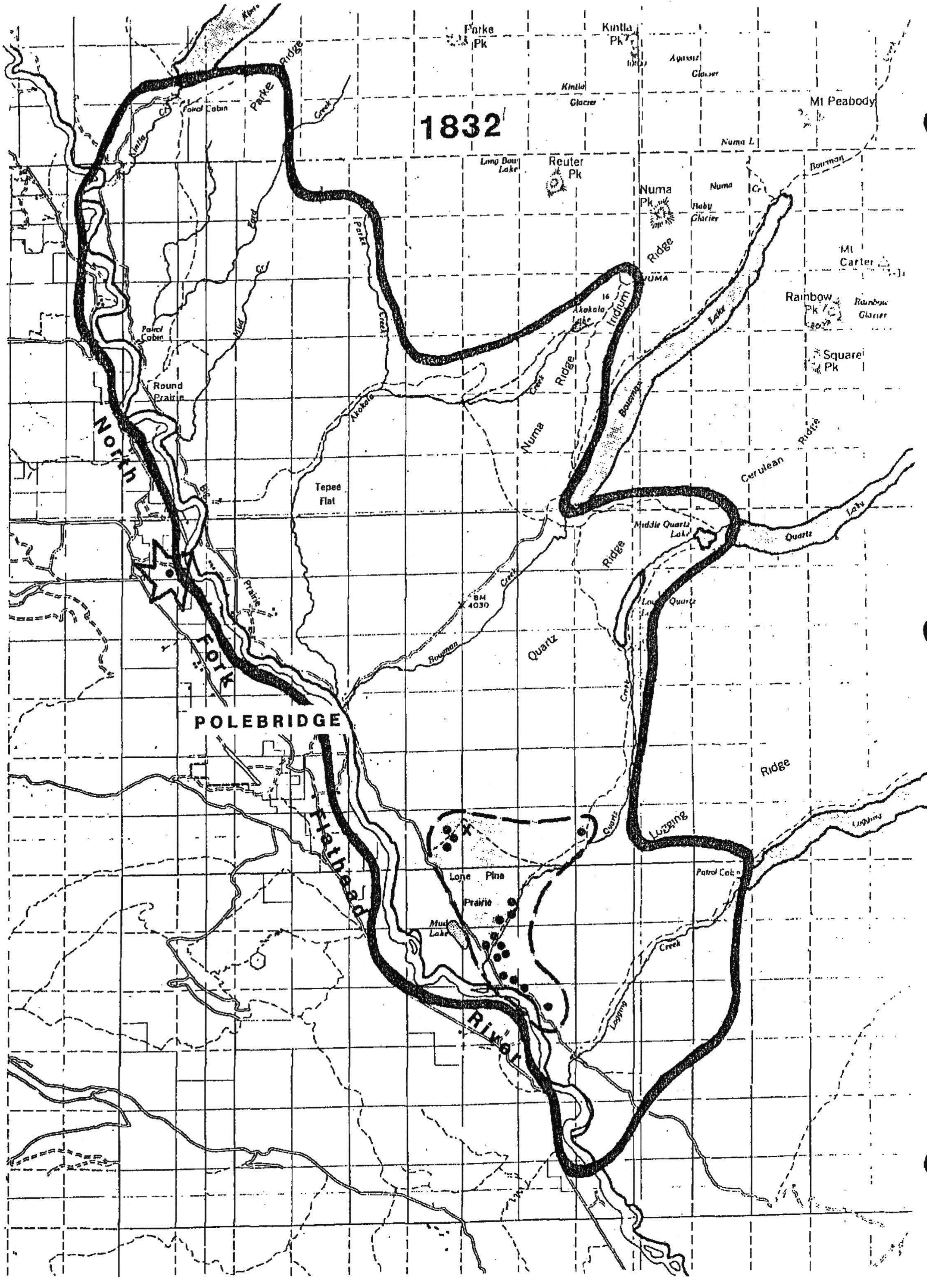

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Numa Pk
Numa Cr
Ruby Glacier
Bowman
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Ridge
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Rainbow Glacier
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Indian Ridge
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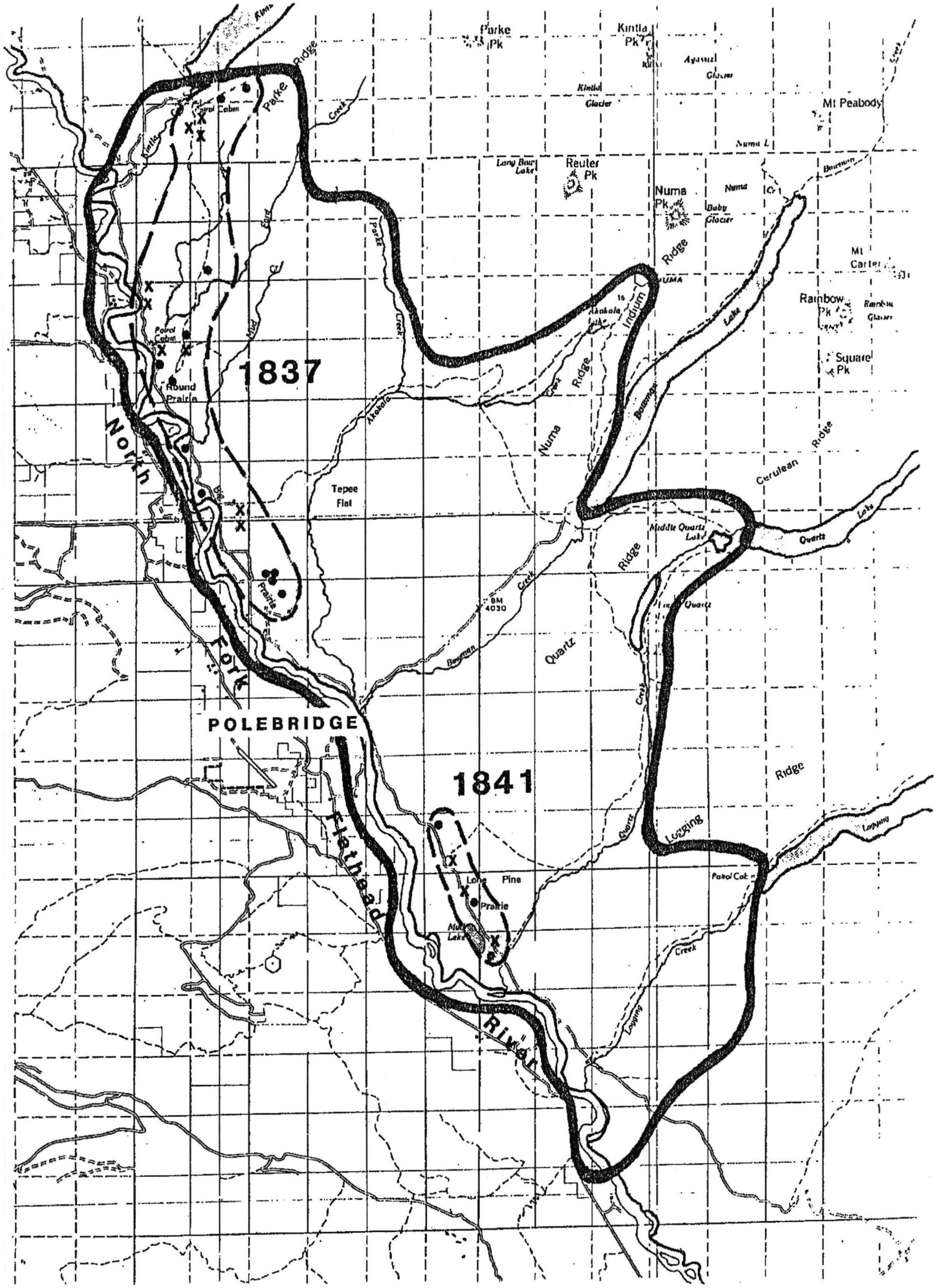
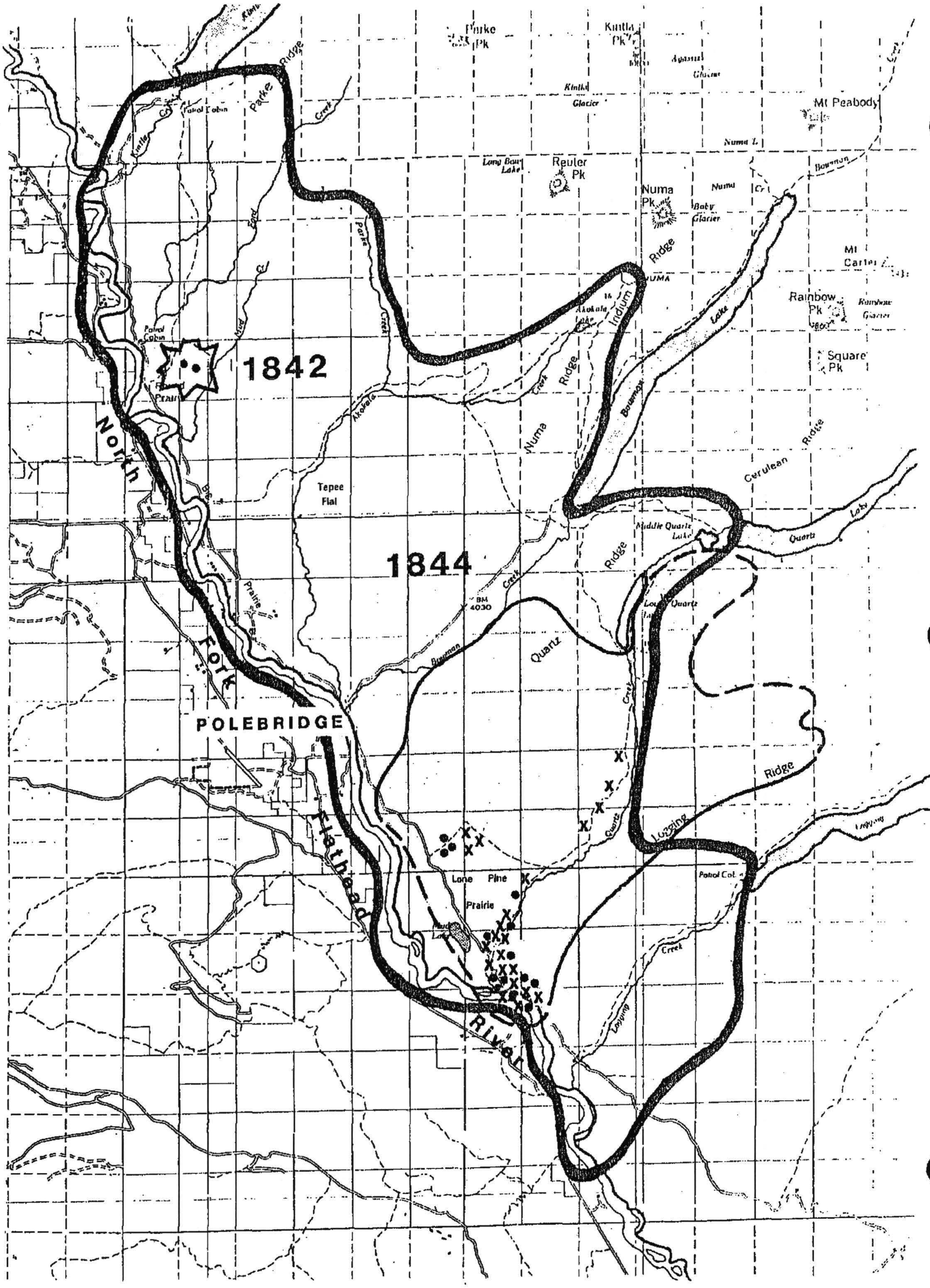
Cerulean Ridge
Middle Quartz Lake
Quartz Lake
Quartz Ridge
Lower Quartz
BM 4030
Bowman Creek
Quartz Creek
POLEBRIDGE
Flathead River
Ridge
Logging
Lone Pine Prairie
Mud Lake
Patrol Cabin
Creek
Logging



Parke Pk
Kintla Pk
Agassiz Glacier
Kintla Glacier
Mt Peabody
Long Bow Lake
Reuter Pk
Numa Pk
Boulder Glacier
Mt Carter
Rainbow Pk
Rainbow Glacier
Square Pk
Parke Ridge
Patrol Cabin
Ford Cr
Parke Creek
Mud Cr
Round Prairie
1837
Akokala Lake
Indian Ridge
Numa Ridge
Akokala
Bowman Lake
Cerulean Ridge
Tepee Flat
Middle Quartz Lake
Quartz Lake
Lower Quartz
BM 4030
Bowman Creek
Quartz Ridge
Quartz Creek
North Fork
POLEBRIDGE
1841
Flathead River
Ridge
Logging Ridge
Logging Lake
Patrol Cabin
Lone Pine Prairie
Mud Lake
Logging Creek



1842
1844
POLEBRIDGE
North Fork Flathead River
Parke Pk
Kintla Pk
Kintla Glacier
Mt Peabody
Reuler Pk
Long Bow Lake
Numa Pk
Boby Glacier
Numa Ridge
Mt Carter
Rainbow Pk
Square Pk
Akokala Lake
Indium Ridge
Bowman Lake
Cerulean Ridge
Quartz Lake
Middle Quartz Lake
Lower Quartz Lake
Tepee Flat
BM 4030
Bowman Creek
Quartz Ridge
Quartz Creek
Logging Ridge
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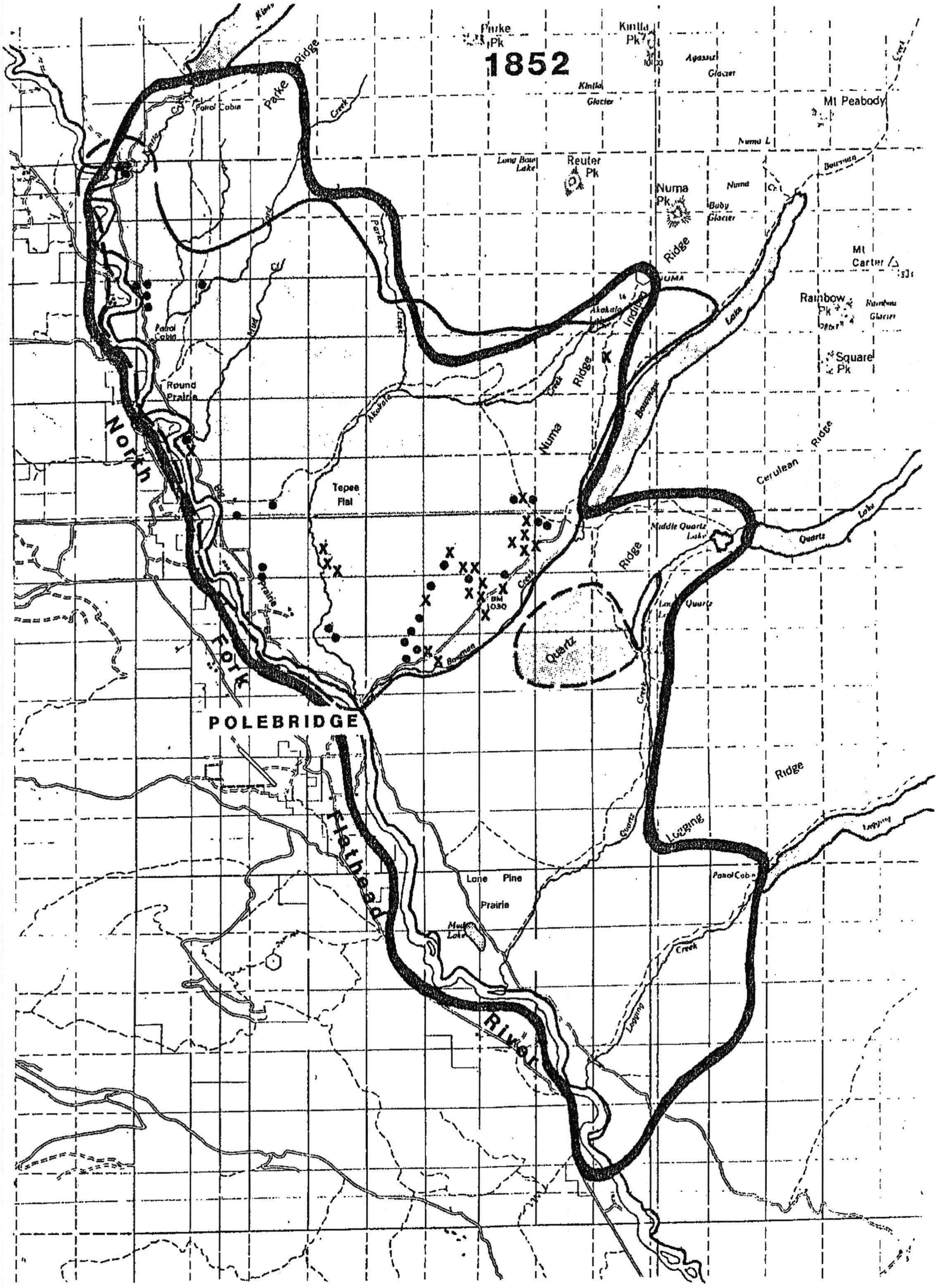
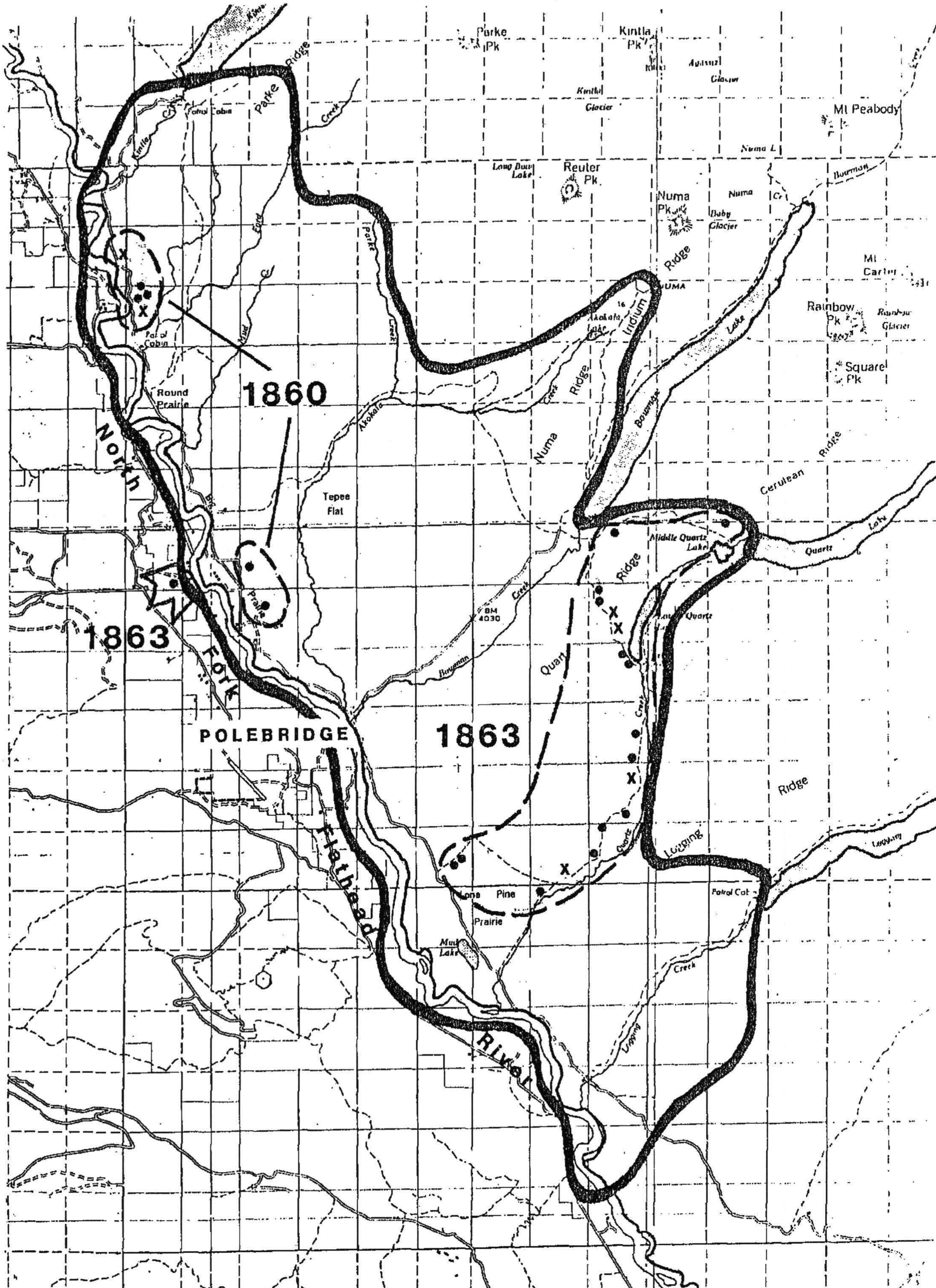
Lone Pine Prairie
Patrol Cabin
Akokala Creek
Numa Creek
Parke Creek
Parke Ridge
Kintla Cr
Ford Cr
Prairie


1852
Parke Pk
Kintla Pk
Agassiz Glacier
Kintla Glacier
Mt Peabody
Parke Ridge
Patrol Cabin
Long Bow Lake
Reuter Pk
Numa Pk
Numa
Baby Glacier
Ridge
Mt Carter
Rainbow Pk
Rainbow Glacier
Square Pk
Patrol Cabin
Round Prairie
Akokala
Indian
Ridge
Bowman
Lake
Numa
Cerulean
Ridge
Tepee Flat
Middle Quartz Lake
Quartz
Ridge
Quartz
North Fork
Flathead
River
POLEBRIDGE
Bowman
Creek
Ridge
Logging
Patrol Cabin
Lone Pine Prairie
Mud Lake
Logging Creek



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Kintla Pk
Kintla Glacier
Mt Peabody
Parke Ridge
Patrol Cabin
Long Bow Lake
Reuter Pk
Numa Pk
Numa Ridge
Numa L
Akokala Lake
Indium
Mt Carter
Rainbow Pk
Rainbow Glacier
Square Pk
1860
Round Prairie
North Fork
Flathead
River
Tepee Flat
Numa
Akokala
Bowman
Cerulean Ridge
Middle Quartz Lake
Quartz
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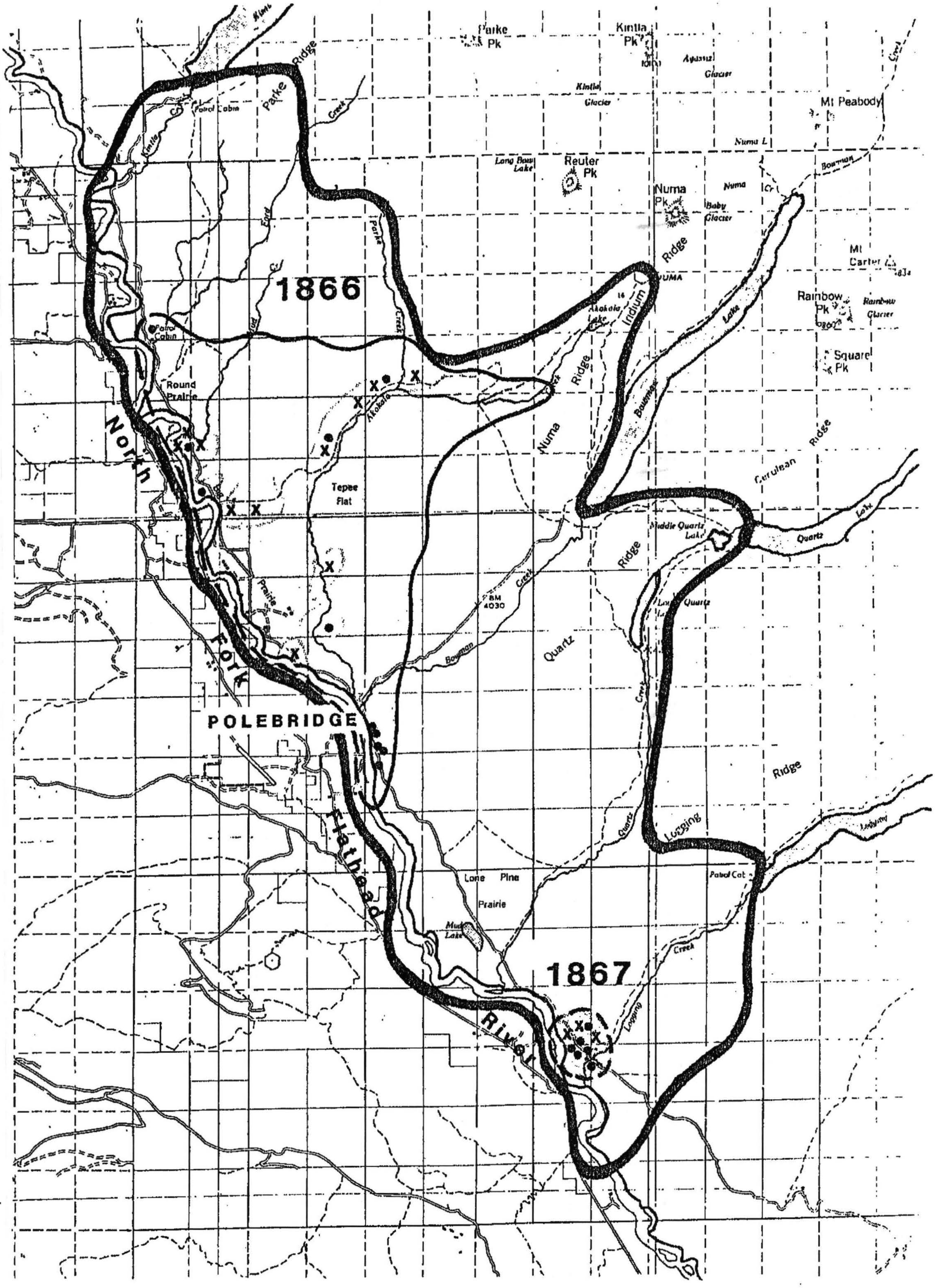
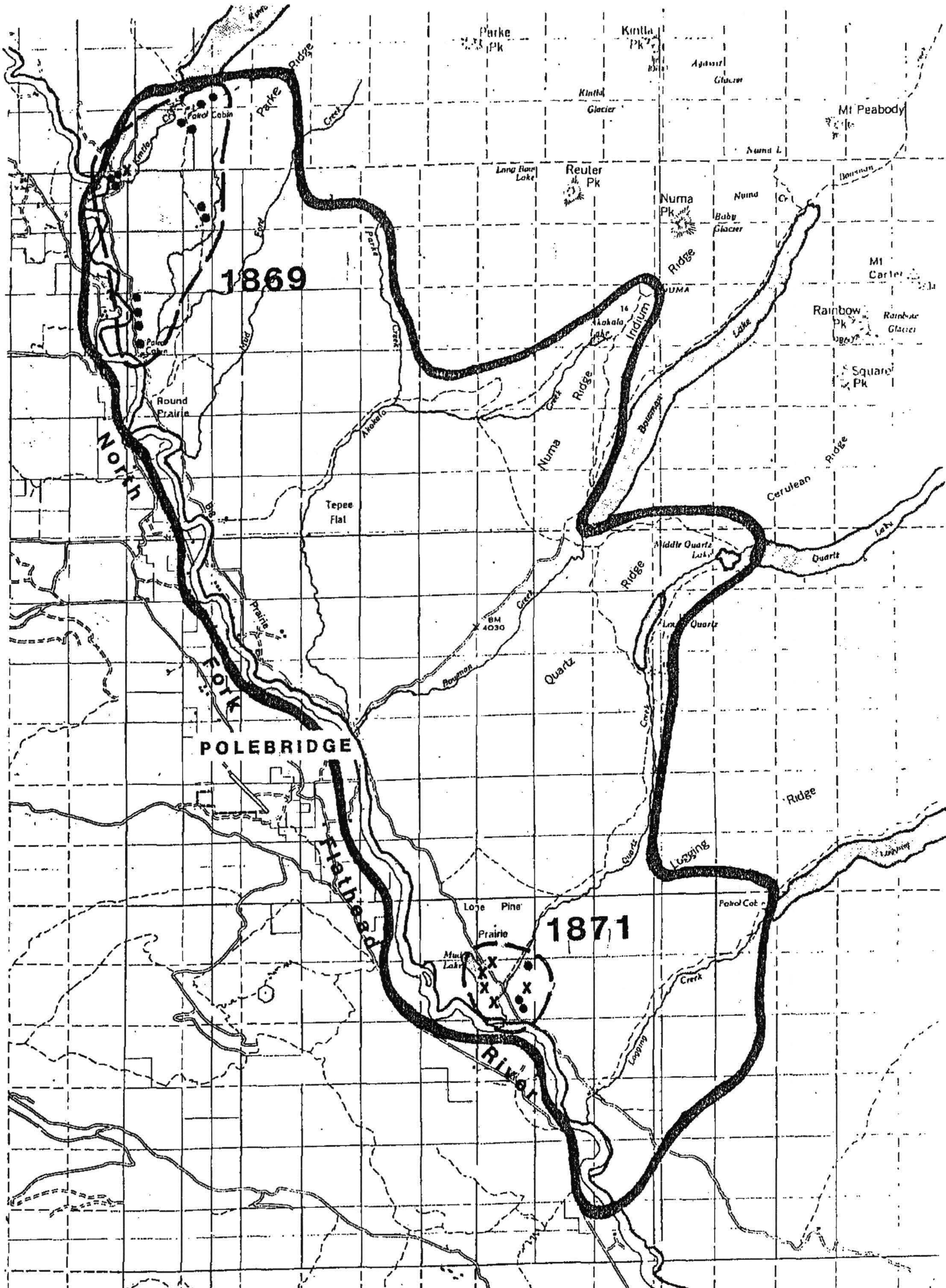
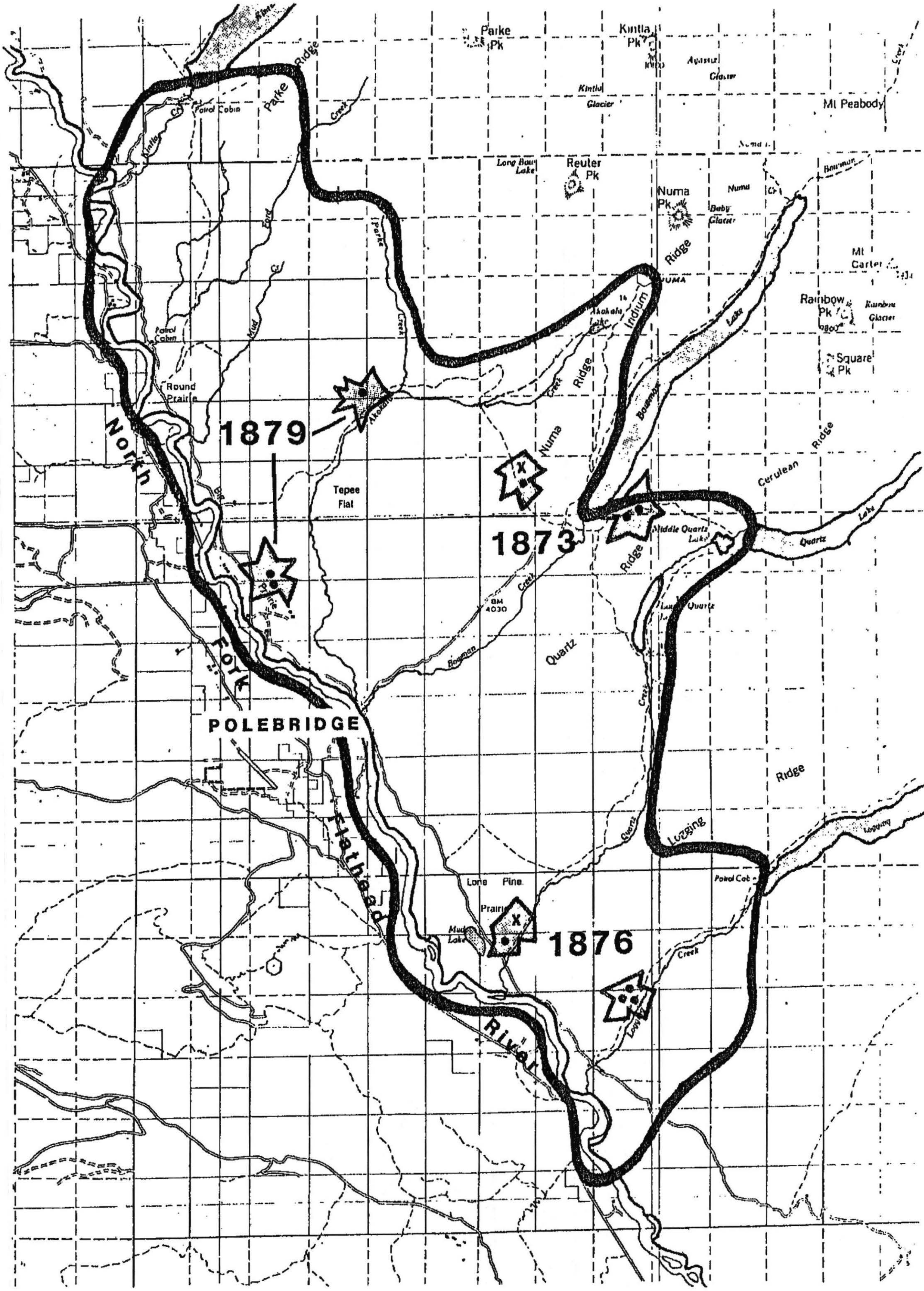
BM 4030
1863
POLEBRIDGE
1863
Ridge
Logging
Lone Pine Prairie
Patrol Cab
Mud Lake
Creek
Logging



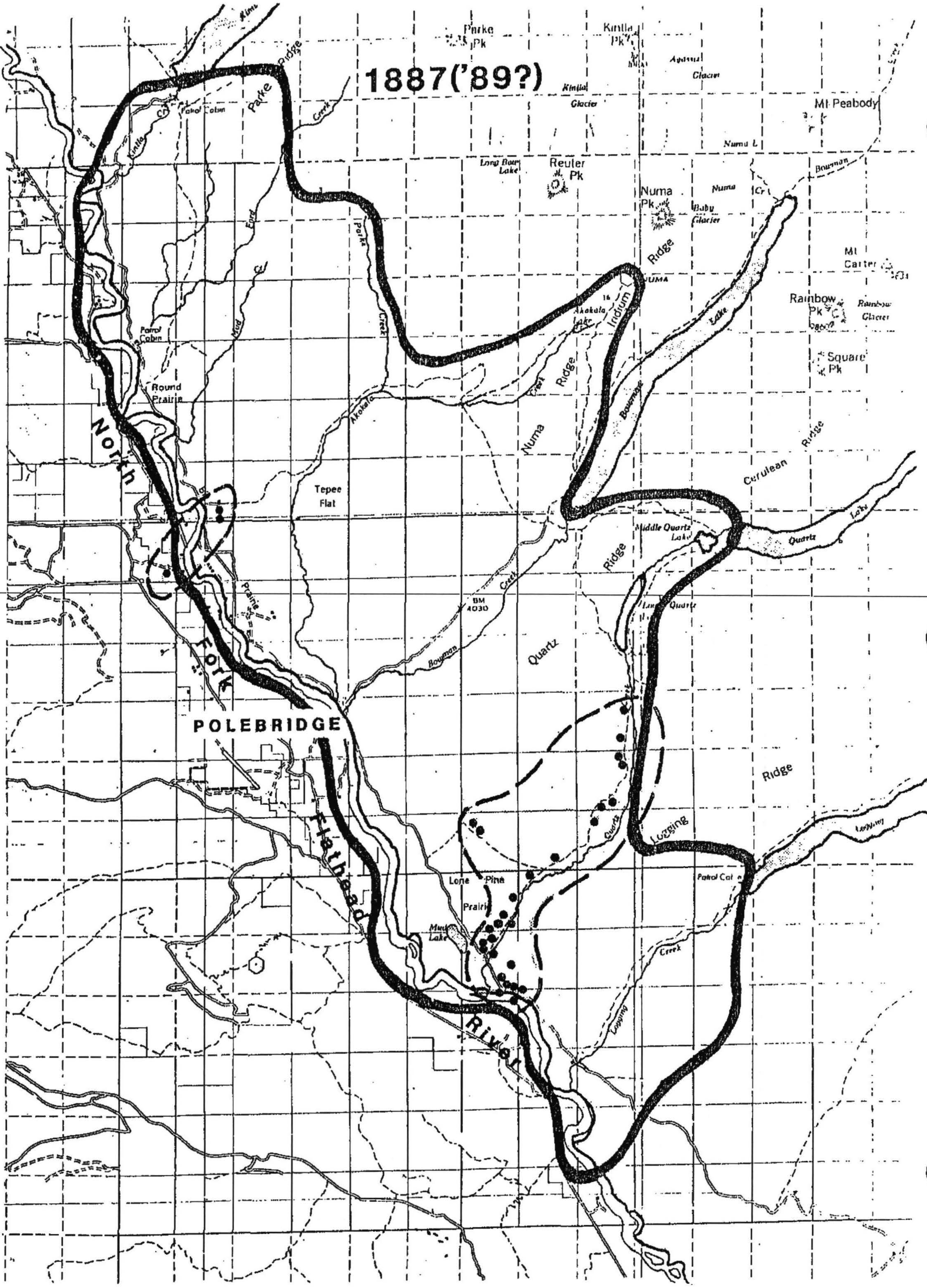
1866
1867
POLEBRIDGE
North Fork Flathead River
Parke Pk
Kintla Pk
Parke Ridge
Kintla Glacier
Mt Peabody
Reuter Pk
Numa Pk
Baby Glacier
Mt Carter
Rainbow Pk
Rainbow Glacier
Square Pk
Akokala Lake
Indium Ridge
Numa Ridge
Bowman Lake
Cerulean Ridge
Round Prairie
Patrol Cabin
Tepee Flat
Middle Quartz Lake
Quartz Lake
Quartz Ridge
Quartz Creek
Bowman Creek
BM 4030
Logging Ridge
Logging Creek
Lone Pine Prairie
Mud Lake



Parke Pk
Kintla Pk
Agassiz Glacier
Kintla Glacier
Mt Peabody
Patrol Cabin
Parke Ridge
Creek
Kintla
Long Bow Lake
Reuter Pk
Numa Pk
Numa L
Bowman
Boulder Glacier
Numa Cr
1869
Ford
Mud
Parke Creek
Ridge
Numa
Akokala Lake
Indium
Lake
Mt Carter
Rainbow Pk
Rainbow Glacier
Square Pk
Patrol Cabin
Round Prairie
North
Akokala
Numa Ridge
Creek
Ridge
Bowman
Numa
Cerulean Ridge
Tepee Flat
Middle Quartz Lake
Quartz
Lake
Ridge
Prairie
BM 4030
Creek
Lower Quartz
Fork
Bowman
Quartz
Creek
POLEBRIDGE
Ridge
Flathead
Logging
Quartz
Logging
Lone Pine
Prairie
Patrol Cab
1871
Mud Lake
Creek
River
Logging



Parke Pk
Kintla Pk
Agassiz Glacier
Kintla Glacier
Mt Peabody
Parke Ridge
Patrol Cabin
Long Bow Lake
Reuter Pk
Numa Pk
Baby Glacier
Mt Carter
Rainbow Pk
Rainbow Glacier
Square Pk
Akokala Lake
Indium
Ridge
Round Prairie
1879
Tepee Flat
Numa
1873
Middle Quartz Lake
Cerulean
Quartz
North
Fork
POLEBRIDGE
Flathead
River
Lone Pine Prairie
Mud Lake
1876
Logging
Creek
Ridge
BM 4030



1887('89?)
Parke Pk
Kintla Pk
Agassiz Glacier
Kintla Glacier
Mt Peabody
Numa L
Long Bow Lake
Reuter Pk
Numa Pk
Baby Glacier
Numa Ridge
Mt Carter
Rainbow Pk
Rainbow Glacier
Square Pk
Parke Ridge
Parke Creek
Kintla Cr
Patrol Cabin
Akokala Lake
Akokala Creek
Numa Ridge
Numa
Iridium
Bowman Lake
Patrol Cabin
Round Prairie
North Fork
Tepee Flat
Cerulean Ridge
Middle Quartz Lake
Quartz Lake
Quartz Ridge
Quartz
Bowman Creek
BM 4030
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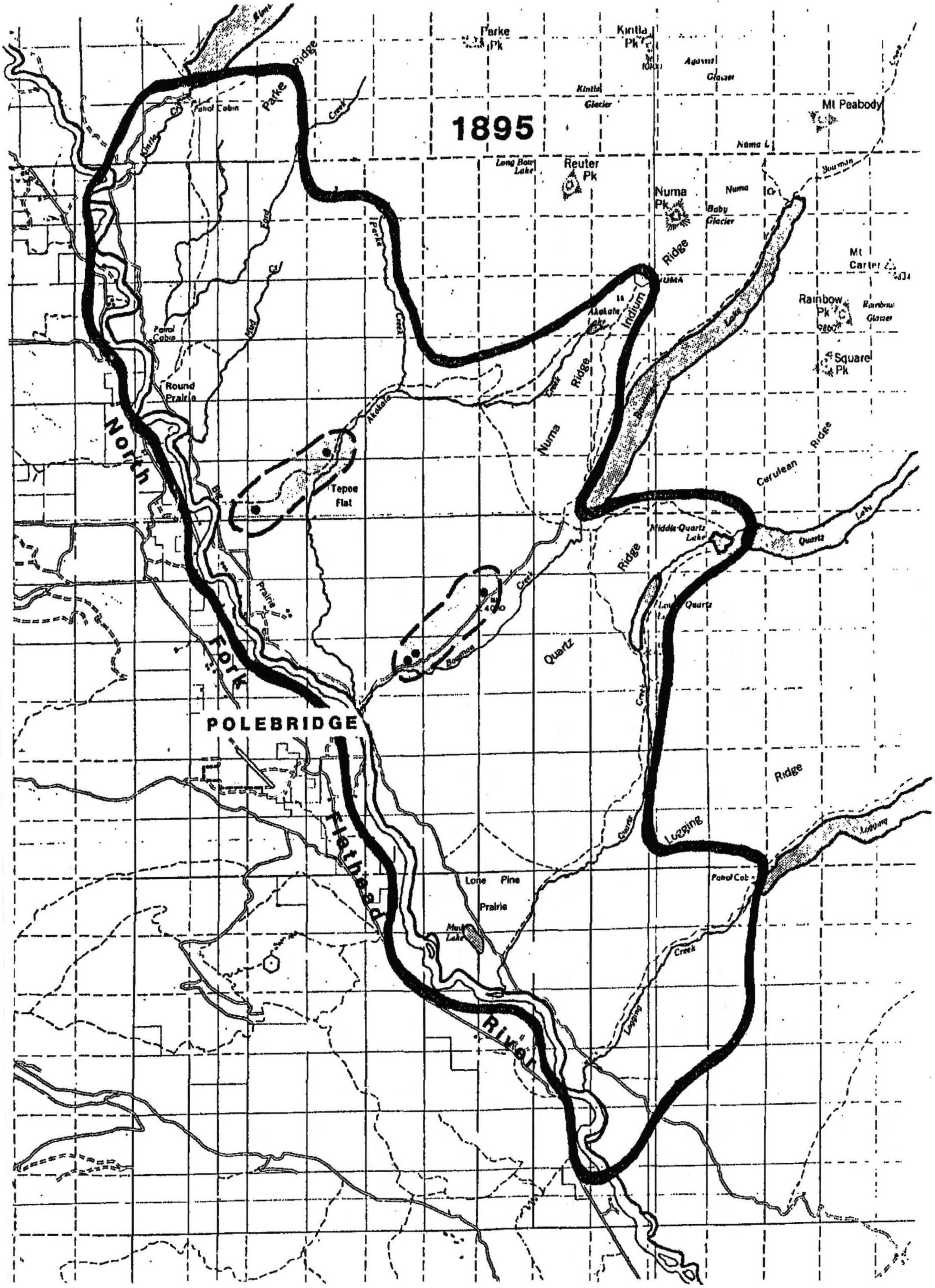
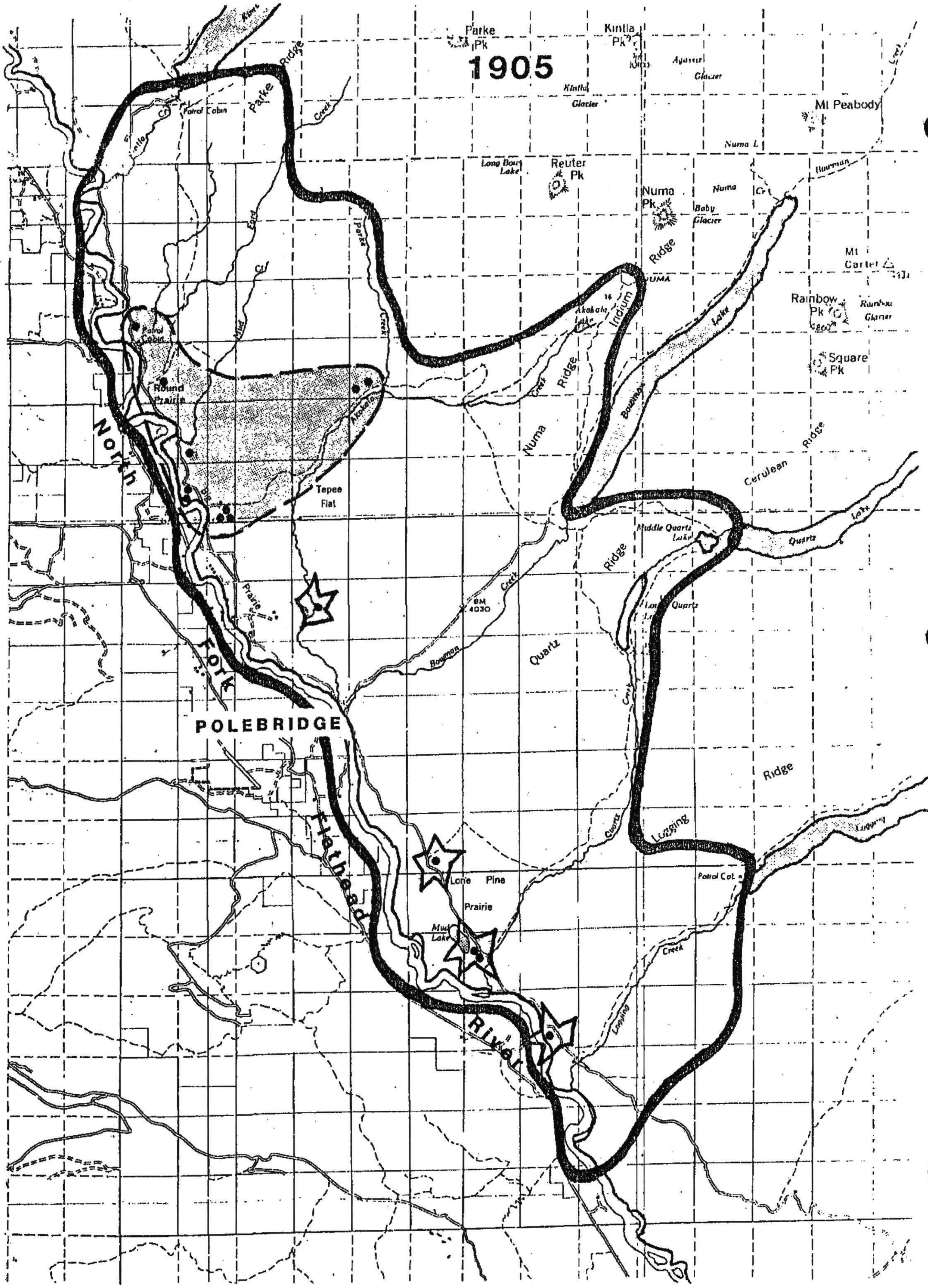
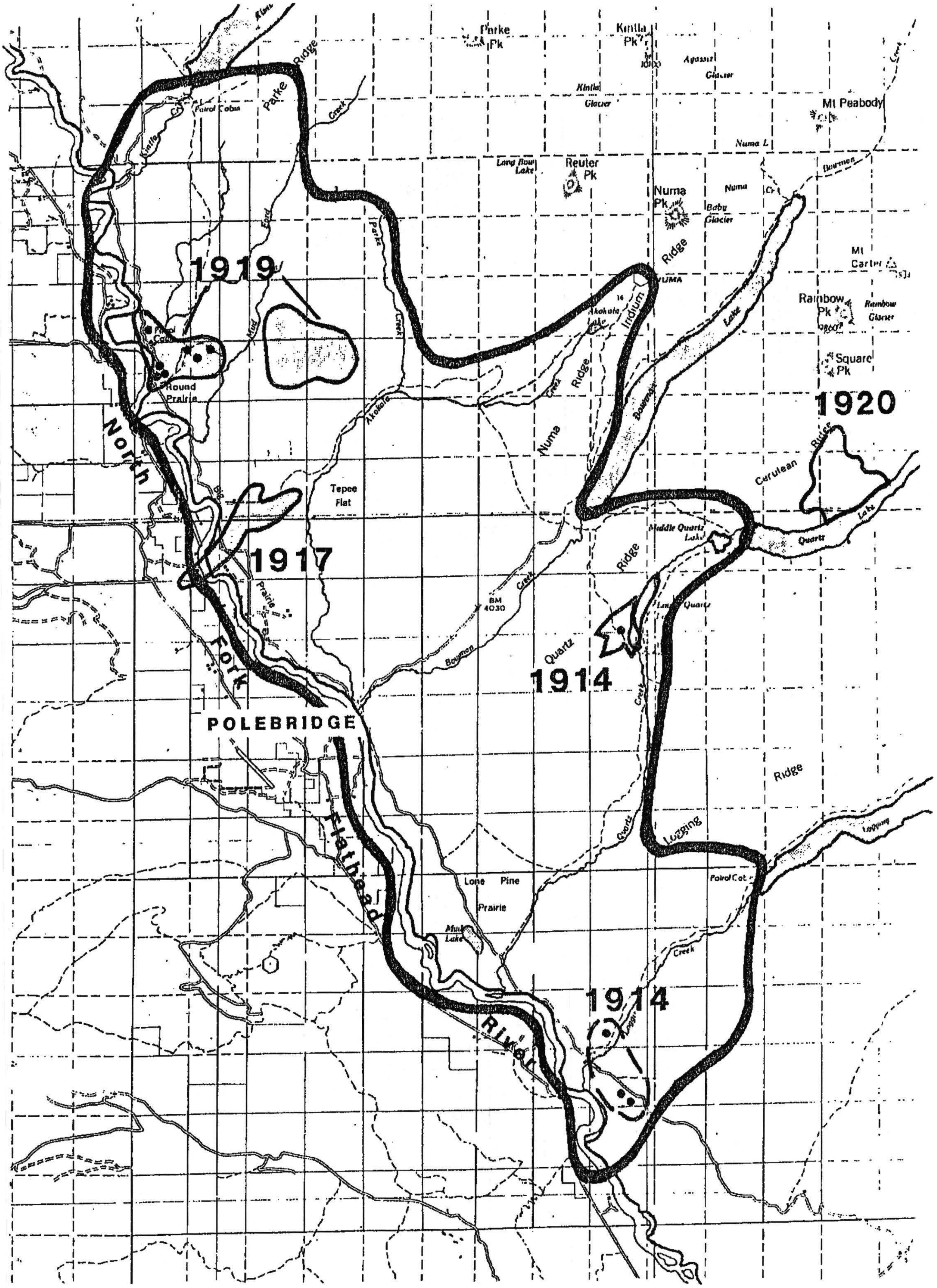
Flathead
River
Ridge
Logging
Logging Creek
Lone Pine Prairie
Mud Lake
Quartz Creek
Patrol Cabin

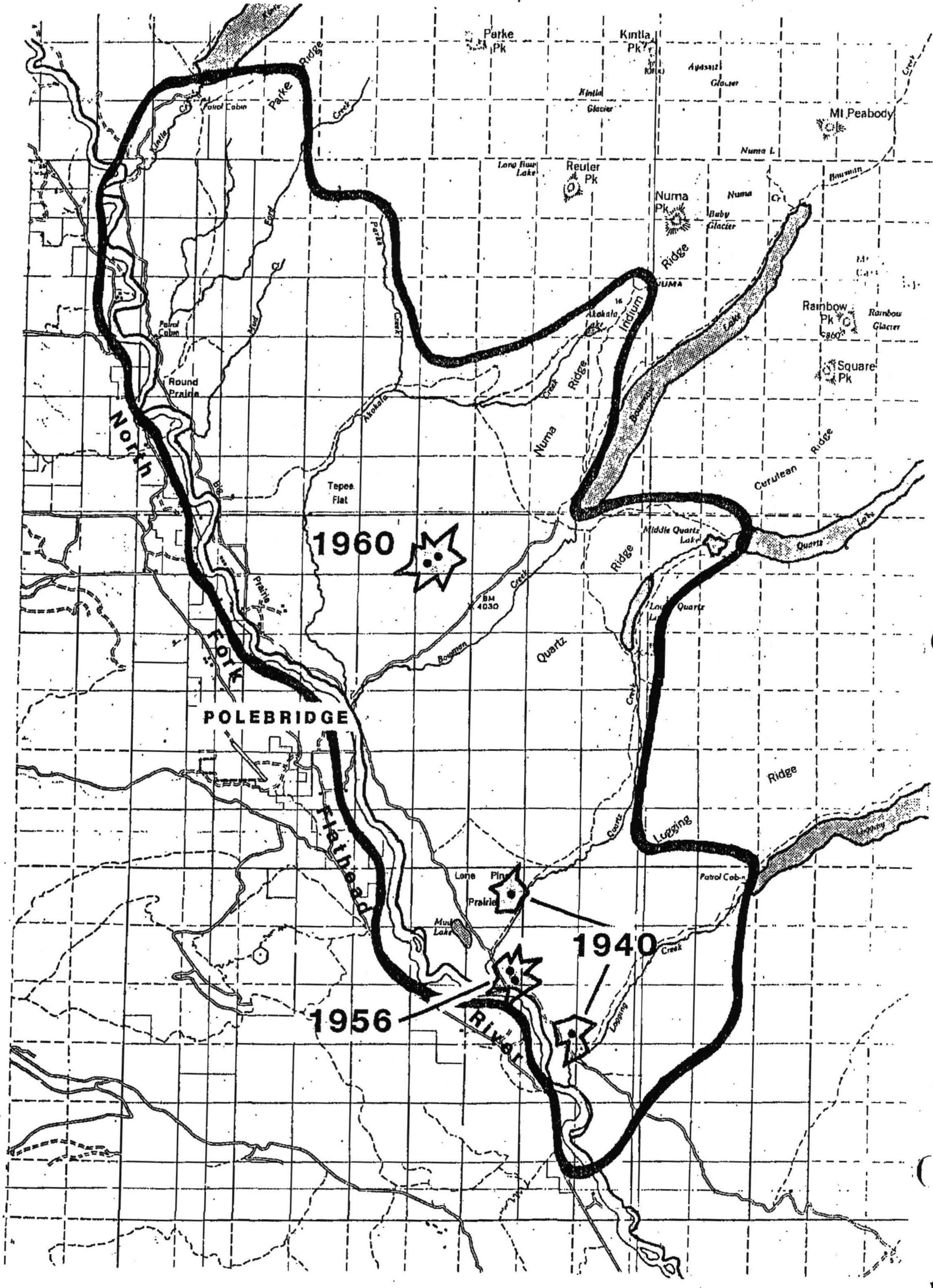


1895
Parke Pk
Kintla Pk
Parke Ridge
Mt Peabody
Reuter Pk
Numa Pk
Numa Ridge
Indium Ridge
Mt Carter
Rainbow Pk
Square Pk
Round Prairie
Tepee Flat
Cerulean Ridge
Middle Quartz Lake
Quartz Lake
Lower Quartz
Quartz Ridge
Quartz Creek
POLEBRIDGE
North Fork Flathead River
Logging Ridge
Logging Creek
Lone Pine Prairie
Mud Lake


1905
Parke Pk
Kintla Pk
Kintla Glacier
Mt Peabody
Numa L
Long Bow Lake
Reuter Pk
Numa Pk
Baby Glacier
Mt Carter
Rainbow Pk
Square Pk
Patrol Cabin
Parke Ridge
Round Prairie
Tepee Flat
North Fork
Akokala Lake
Iridium
Numa Ridge
Bowman Lake
Cerulean Ridge
Middle Quartz Lake
Quartz Lake
Quartz Ridge
BM 4030
Bowman Creek
POLEBRIDGE
Flathead
Lone Pine Prairie
Mud Lake
Logging Ridge
Logging Lake
Logging Creek
River



Parke Pk
Kintla Pk
Agassiz Glacier
Kintla Glacier
Mt Peabody
Numa L
Long Bow Lake
Reuter Pk
Numa Pk
Baby Glacier
Mt Carter
Rainbow Pk
Rainbow Glacier
Square Pk
Parke Ridge
Patrol Cabin
1919
Round Prairie
Numa Ridge
Indian Ridge
Akokala Creek
Bowman Lake
1920
Cerulean Ridge
Quartz Lake
Middle Quartz Lake
Lower Quartz
Quartz Creek
Quartz Ridge
Tepee Flat
1917
North Fork
Big Prairie
BM 4030
Bowman Creek
1914
POLEBRIDGE
Flathead River
Lone Pine Prairie
Mud Lake
Logging Ridge
Logging Lake
Patrol Cabin
Logging Creek
1914



Parke Pk
Kintla Pk?
Kintla Glacier
Agassiz Glacier
Mt Peabody
Numa L.
Long Bow Lake
Reuter Pk
Numa Pk
Baby Glacier
Bowman
Rainbow Pk
Rainbow Glacier
Square Pk
Patrol Cabin
Parke Ridge
Parke Creek
Akokala Lake
Indium Ridge
Numa Ridge
Round Prairie
North Fork
Tepee Flat
1960
BM 4030
Bowman Creek
Akokala Creek
Cerulean Ridge
Middle Quartz Lake
Quartz Lake
Quartz Ridge
Quartz Creek
POLEBRIDGE
Flathead River
Lone Pine Prairie
Mud Lake
1940
1956
Logging Ridge
Logging Creek
Patrol Cabin